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ABSTRACT

Written principally for students in grades five through seven, this handbook furnishes experiments, investigations, and field studies for students to complete largely on their own. Gaining a foundation of the skills and knowledge to become environmentally literate citizens is the goal of the activities. Units of study consider plant ecology, aquatic ecology, plot studies, environmental degradation, geography, and measurement. Each exercise outlines general background information, objectives, and procedures for conducting the activity followed by a data sheet to record the observations. A key to the woody plants of the Beartooth Mountains is appended. (BL)

Exploring the World

-an Environmental Education Handbook ---for Students

EXPLORING THE WORLD

-- a Handbook of experiments, investigations, and field studies to assist students in the "middle grades" gain a good foundation of the skills and knowledge to become "environmentally literate" citizens.

-- prepared initially for the

Environmental Education Program of
School District #2, Billings, Montana.

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February 1972

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PREFACE

To the Student --

This Handbook was written for you and is addressed to you. You, as a young person today, will soon be an adult, and will inherit from us (the adults of today) a nation and a world that has many, many problems -- problems of pollution, of land destruction, of decaying and suffocating cities, of decreasing amounts and quality of many resources, of space to live well and happily. Many of these problems have solutions. Some of the solutions are starting to be applied today. And you, when you are an adult, can help greatly to speed the applying of solutions.

But in order to help make this world a better place, "fit for life and fit for living", all of us need to understand how plants, animals, and people affect each other and are affected by the physical world around them. We need to appreciate that all life is part of a vast and complex "Web of Life." We need to realize that people are part of this web, and that man, in destroying the Web of Life and the air, water, and soil base of the Web, also destroys himself.

In this Handbook are many activities to give you the skills you need in order to learn how this old world works. With these skills you can then explore the world, by carrying on studies and investigations of various natural ecosystems or communities of plants and animals. You can start to learn what affects man has on natural communities, how man's own communities too are "human ecosystems", and how the same biological and physical principles apply to both. With this knowledge and ability, plus knowledge of man's social and economic systems, you can then logically and sensibly attack and help solve, as an active citizen, many of today's environmental problems.

All of the skills, activities, investigations, studies, and experiments in this Handbook have been done by hundreds of young people. They are written for you to do yourself, or with partners. Your teacher is just a guide, to help you when and if you get stuck. Follow the directions of each unit carefully. Collect and record your data accurately. Draw your conclusions. Search for other solutions. And start applying these ideas to your own world of school, home, and town.

To the Teacher:

This Handbook is a loose-leaf, three-hole booklet so that as more units are prepared, they can be easily inserted in your copy and in the copies your school children have. The units are written for the children to do largely on their own. Your part is to help gather the materials for units, and to help the students select units that will gradually build their skill and knowledge. We want you in your classroom and out of doors to encourage experiments and investigations, data collection, discussion, and the search for alternative solutions of problems. As the children gain these skills and attributes of investigation and inquiry, direct them more and more towards human ecosystem studies, eventually leading to active participation in helping to solve problems. By doing this you will help children --

1. -- to become knowledgeable about their total environment.
2. -- to become skillful in how to find out about problems or situations.
3. -- to become sensitive to their role in and responsibility to developing a productive and liveable environment.

4. -- to become motivated to work constructively towards solutions of environmental problems.

More Later

This Handbook will be gradually expanded as more units are added. They will be distributed through the teachers to the students in the Billings program.

Level

Most of these units are written on the 5th to 7th grade levels, and all of them have been used with children in the field. The teacher can guide the students in selection of units, but the performance of the individual units should be largely by the students.

Info Material #000

About Systems of Units of Measurement

Of all of the nations of the world, the United States is almost the only one that is not using the Metric System of measurements. We're so used to our own system that it seems simple to us -- yet conversions within our own system are really a mess.

In contrast to our system, the Metric System is a decimal system -- just like our money system. And there is a growing movement in industry and government aimed at gradually converting the United States to the Metric System. It already is the universal measurements system in science. This switch to the Metric System probably will occur in the lifetimes of present elementary school children.

In this Handbook, we have in many of the experiments and investigations suggested and encouraged the use of metric units. They really are very logical.

The basic "language" of metric units involves really only three terms or prefixes:

milli -- means one one-thousandth
centi -- means one one-hundredth
kilo --- means one thousand times

(there are other terms, such as deci, deca, hecto, but they are seldom used).

The basic units are the meter (for length), and the gram (for weight or mass). Area units involve a length and a width multiplied together -- or two length units -- and are labelled square meters, square centimeters, and so on. Another area unit is the hectare. Volume units involve a length, a width, and a height multiplied together -- or three length units -- and are labelled cubic meters, cubic centimeters, etc. Also, in volumes the metric system also uses a unit called the liter.

In many books you will find many conversion figures from our system to the metric system. But really all you need to remember is one conversion for length, and one conversion for mass or weight. This can be your "bridge" from one system to the other. (For a simple description of measurements and how to convert them, see "Summaries and Problems in General Physical Science", by W. F. Clark, EMC Bookstore.)

Here are some conversions that will be useful:

Our System	Kind of Unit	Metric System
1 inch = 2.54 centimeters 1 yard = 0.9144 meters 1 mile = 1.609 kilometers	Length	1 meter = 39.37 inches 1 kilometer = 0.621 miles
1 square yard = 0.836 sq. meters 1 square mile = 2.59 sq. kilometers 1 acre = 43,560 square feet and also = 0.405 hectares	Area	1 sq. meter = 1.196 sq. yds. 1 sq. kilometer = 0.386 sq. miles 1 hectare = 10,000 sq. meters and also = 2.471 acres
1 quart = 0.946 liters (liquid measure) 1 cubic yard = 0.764 cubic meters	Volume	1 liter = 1000 cubic centimeters 1 liter = 1.056 quarts 1 cubic meter = 1.308 cubic yards
1 ounce = 28.35 grams 1 kilogram = 2.205 pounds	Weight	1 gram = 0.035 ounces (avoir) 1 pound = 454 grams = .454 kilograms

PLANT ECOLOGY UNIT

Exercise I: "WHO AM I"

Before one can study plant ecology, one must be able to recognize and name the plants growing in a study area. In the study area that you will investigate are about 80 different plants. I am sure that you are asking the question: "I know a few plants but how am I suppose to know all those plants?" Don't feel bad as your teacher and biologists have the same problem. Biologists have come up with a neat way to find out the name of a plant without memorizing hundreds of different plants. The method is called a plant key.

Objectives

1. At the end of this exercise you will be able to observe differences in color, shape, arrangement of stems.

2. At the end of this exercise you will be able to construct a key to the 10 plants in the paper bag based on stem characteristics.

The Experiment

1. Empty the contents of the bag on your desk. Be careful not to break off the buds or leaves. Watch out for thorns and stickers.

2. Now separate the twigs into two separate piles on your desk based on some observable characteristic.

EXAMPLE

Let's make a key to the students in the sixth grade at Broadwater School. We will divide the students into two groups based on some characteristic.

How about dividing them into boys and girls? That's easy, but now we must describe the characteristics that we used to separate the boys and girls.

1a. Student with long hair, usually covering the ear; knees not covered by clothing.

1b. Student with short hair, usually some of the ear showing; knees covered by clothing.

We now have divided the class into two separate groups. We used two characteristics for separating the students. Plant stems are just like students because they all don't fit into neat little piles. For example, Kirk has long hair while Jane has short hair and this is why you always need two characteristics.

---

3. At the end of this exercise you will find a data sheet. Now write in your own words how you separated your pile of twigs.

1a. Twigs with needles or green leaves growing along stem; buds found only at the end of the twigs.

1b. Twigs without needles or green leaves; buds found along the stem.

Now many times it is difficult to put in words these descriptions so you will also draw little pictures.

4. Take all the stems that fit your 1b classification and put them in a neat pile on the floor so you or your fellow classmates won't step on them.

5. Now separate the 1a pile into two piles based on some characteristic.

Now we will separate the girls in the Broadwater sixth grade room. We will come back to the boys later.

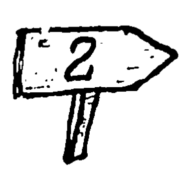
2a. Student with red hair; freckles across nose 3

2b. Hair various colors but not red, freckles sometimes present

Now we will go back to 1a and put up a road sign for others to follow

1a. Student with long hair, usually covering the ear; knees not covered by clothing 2

Note the 2 at the end of the line is the road sign



all girls go to two

Now put a road sign at the end of line 2a to direct traffic

3a. Student with braces on teeth; feet large, size 8 Mary

3b. Student without braces on teeth; feet small, size 4 Shelly

We have now separated Mary and Shelly from all the other students in the Broadwater sixth grade room. Let's use Mary for an example.

Mary is a girl so she would fit the 1a group and would be sent on to the group 2 separation. Since Mary has red hair and freckles she would fit the 2a group and be sent on to the group 3 separation. Now most of the time Mary has her mouth

open yakking away, but for those rare moments when her mouth is closed we can still separate her from Shelly based on the size of her feet.

---

6. Now go to the data sheet and using the group 2 lines separate your twigs.

   2a. In this space you will write the two characteristics of one group of stems from <u>1a</u>.

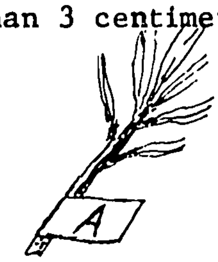
   2b. In this space you will write the characteristics of your second group from <u>1a</u>.

7. Now put up the road sign behind <u>2a</u>  which sends them to group 3.

8. When you have separated one of your stems from all other stems wrap a piece of tape around the stem and write a letter on the tape to identify that stem from all other stems. Don't worry about a name for your twig as in a latter exercise we will go into naming the twigs.

   3a. Needles greater than 3 centimeters and in bundles of 5's (A)

   3b. Needles less than 3 centimeters and single 4



9. Now place the stem with the tape that you have separated back in the paper bag so it doesn't get mixed up with the other stems.

10. Continue to separate the stems into piles.

11. When you have separated all the members of the <u>1a</u> group pick-up the group of stems that you placed on the floor. Now go back to the <u>1b</u> line of the 1-group. At the end of the line put up a road sign to direct the stem. Let's say that you have used all of groups 2, 3, 4 and 5 so the sign would read 6.

    1b. ----------------6

12. Continue the 1b group until they have all been separated.

13. When you have finished take you key and your bag of marked twigs to your teacher. Your teacher will take a stem from the bag and follow it through your key. Your key must work on at least 7 out of the 10 stems in the bag. If it doesn't meet this standard it is back to the drawing board.

14. Best of luck my fellow ecologists.

DATA SHEET
"WHO AM I"

1a. ______________________________

____

1b. ______________________________

____

2a. ______________________________

____

2b. ______________________________

____

3a. ______________________________

____

3b. ______________________________

____

4a. ______________________________

____

4b. ______________________________

____

5a. ______________________________

____

5b. ______________________________

____

6a. ______________________________

____

6b. ______________________________

____

7a. ______________________________

____

7b. ______________________________

____

8a. ____

____

8b. ____

____

9a. ____

____

9b. ____

____

10a. ____

____

10b. ____

____

11a. ____

____

11b. ____

____

12a. ____

____

12b. ____

____

13a. ____

____

13b. ____

____

14a. ____

____

14b. ____

____

15a. ____

Exercise II: "The Mystery Key"

An ecologist must be able to communicate with his fellow ecologists. People who study plants over a period of many years use various terms to describe the structure of plants. Some of these commonly used terms are found on pages 5 - 9 in the Key to the Woody Plants of the Beartooth Mountains. You will pick some stems and make a key using simple clear terms so that your fellow classmates and teacher can follow your key.

Objectives

1. At the end of this exercise you will have made a key to 10 different woody plants that you have collected.

2. You will use at least 10 standard plant terms found in Figure 1 in your key.

3. Any student, even your teacher, will be able to separate the plants that you have collected using your key.

The Experiment

1. Collect 10 woody twigs. Don't get mixed up and bring in some old dryed up weeds. Try to collect the most un-alike plants that you can find because it is easier to build a key for them than if they are very similar.

2. Now go through the same steps as you took in Exercise I. At the end of this exercise you will find a data sheet for your key. Make your key very simple and clear so your fellow classmates can follow. If little drawing along the margin will help him, be sure and put them in.

EXAMPLE

3a. Leaves on stem awl-shaped, less than 1 cm in length

3b. Leaves needle-like, longer than 1 cm in length

---

3. Remember during the last Exercise when you separated one plant from all other plants, you gave it a letter name.

EXAMPLE

5a.	Stem red in color, little white dots are found along the stem	C
5b.	Stem brown in color, bark smooth and the same color	6

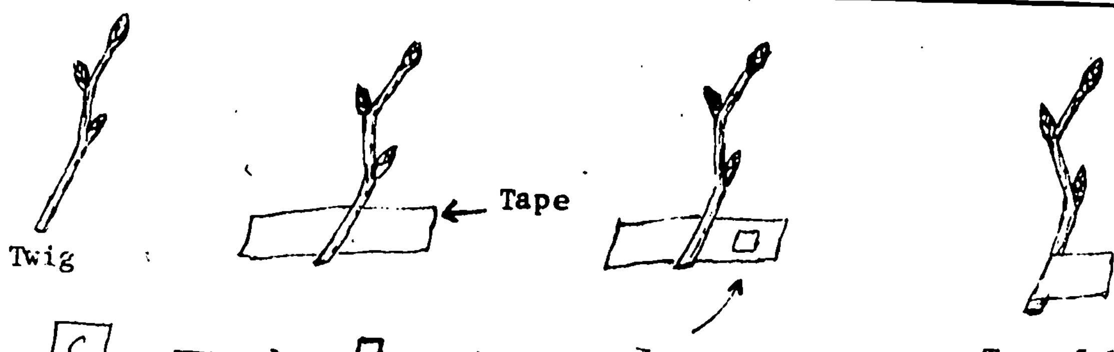
(You have called this twig C. Later you will be able to give it a name.)

---

4. Now remember that this is a "mystery key". Instead of writing the letter C on the outside of the tape that you put around the stem, take a small piece of paper, write the letter C on it, fold it and place it between the two ends of the tape so on one can see the letter that you have written.

Exercise II

EXAMPLE



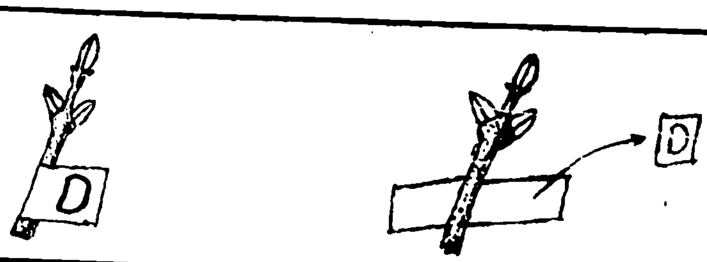
5. Continue separating your plants and placing the clues inside the tape on the stem.

6. When you have finished, put all your stems in the paper bag along with your key. Be sure your name is on the outside of the bag as well as on the key. Take the bag to the teacher. Now the teacher will give you a bag of twigs with a key made by one of your classmates in exchange for yours.

7. Take a twig from the bag and follow it through the key. Let's say that you key it out to be plant D. Write a D on the outside of the tape. Continue keying the plants until you have identified all the stems in the bag.

8. Take the bag of twigs to the teacher and she will call the student that made the key. The three of you will then open the tape and take out the plant clue. Now if everything works right the letter on the plant clue should be the same as that on the outside of the tape.

EXAMPLE



"Congradulations, you are a winner!"

Evaluation: Your fellow classmate must be able to key 8 out of the 10 twigs using your key. If he fails to do so, we must think that your key wasn't too clear and go back to the drawing board. If your fellow classmate is able to key 8 of the 10, proceed to the next exercise.

MYSTERY KEY

This key was designed by the world's greatest ecologist.

1a. ______________________________

____

1b. ______________________________

____

2a. ______________________________

____

2b. ______________________________

____

3a. ______________________________

____

3b. ______________________________

____

4a. ______________________________

____

4b. ______________________________

____

5a. ______________________________

____

5b. ______________________________

____

6a. ______________________________

____

6b. ______________________________

____

7a.__________

7b.__________

8a.__________

8b.__________

9a.__________

9b.__________

10a.__________

10b.__________

11a.__________

11b.__________

12a.__________

12b.__________

13a.__________

13b.__________

Exercise III: Camp Plants

You now know how to make a key and how to use a key. Look what else you have done in the last few days. You can look at stems and leaves and see many things that other people overlook. Now you are becoming a biologist. In the exercise you are about to start, you will start putting names to the twigs instead of calling them stem A, B, or C. The key that you are going to use was developed for camp where you will spend two days. You recall the trouble you had with your key, well you are not alone. We are sure that we have made mistakes in ours so would you please point these errors out to your teacher and she will tell us.

OBJECTIVES:

At the end of this exercise you will identify 7 out of 10 stems collected at the camp using the "Key to the Woody Plants of the Beartooth Mountains."

THE EXPERIMENT:

1. Take a bag of plants and record the letter on the bag on your data sheet. This is important as different bags contain different kinds of stems. <u>Please</u> don't put your stems into another bag or everything will be goofed up.

2. You will see that the key is divided into different ecosystems. The plants in the bags were collected from the stream side hardwood ecosystem.

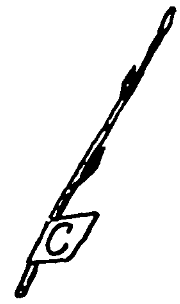
3. You will run into a lot of new terms using this key. If you have trouble there are drawings of different types of leaves, buds and stems on pages 5 and 6. You will also find a glossary of terms on page 7. Use these terms as often as possible when talking to your fellow classmates and you soon will learn biology talk.

4. At the bottom of each stem is a letter on a piece of tape. Now check the data sheet and find the same letter. When you have identified the stem, write the name of the stem in the blank.

EXAMPLE

Camp Plants
Data Sheet

Stem Letter	Plant Name
A	
B	
C	Bebbs Willow



EVALUATION:

When you have completed your bag of 10 stems take your data sheet to your teacher. Your teacher will quickly check them off. If you keyed 7 out of the ten correctly, start the next unit. The last exercise of this unit will be completed at camp. If you didn't fare so well, don't feel bad. Plants are tough to key. Ask your teacher for a different bag of stems and do it again.

DATA SHEET

FOR THE CAMP PLANTS

LETTER ON STEM OF PLANT	NAME OF PLANT	BAG #
A	______________	________
B	______________	________
C	______________	________
D	______________	________
E	______________	________
F	______________	________
G	______________	________
H	______________	________
I	______________	________
J	______________	________

Exercise IV: Nearest Neighbor

Welcome to camp! Remember how you worked and worked on the plant keys and identification of twigs. This is the exercise that requires the skills you developed back at Billings. You are going to conduct a terrestrial ecology study. When you ask a person who has never studied ecology a question about a plant community, he will more than likely say the community contains a bunch of evergreens, grasses and flowers. You and I know that ecology is both quantitative and qualitative since it is a science. In our study of terrestrial (land) ecosystems we will attempt to figure the quantitative and qualitative relationships between the abiotic and biotic parameters. Since the time is so limited, we will only work with the woody plants.

Objectives:

(1) Each team of three students will identify by use of the "Key to the Camp Plants", selected trees and shrubs at 10 points along a transect.

(2) From the data collected, each team will determine the ecosystems along the transect.

(3) Each team will hypothesize why the ecosystems change along the transect.

The Experiment:

1. A counselor will take your team to a starting point on a transect line. Each transect has different colored stakes. For example, one is orange; one blue and so on. This is so you don't get mixed up and switch to another transect. The stakes are at 25 meter intervals along the transect. Each stake on the transect line is numbered and this number should always correspond to the number on your data sheet. Since there are many teams working on this exercise and also because we need replications(reps as we so often call them) of our scientific work, one team will start at one end of the transect and another team at the other end. Some place near the middle you will meet this other team working in the opposite direction.

2. When you arrive at the starting point, check the number on the stake. It must either be a 1 or 10, otherwise you are not at the end of the transect. When you record the data for this stake, be sure it corresponds to the same stake number on your data sheet.

3. Measure the distance from the stake to the nearest tree. Record this figure in the proper column of your data sheet.

4. Now identify the tree using the "Key to the Camp Plants." In the front of the key are a set of illustrations or drawings of different ecosystems. You will recall that in Billings you only used the hardwood river bottom key. Look at the area and match it with one of the illustrations. At the bottom of the illustration it will tell which page you will find the key to the plants of that ecosystem. Record the name of the tree that you identified in the stake species column.

5. Now measure the distance from the tree that you have just identified to its nearest tree neighbor. Record this figure in the (4) column. Identify the nearest neighbor tree using the key and record your finding in (3) column.

6. You will notice that in most ecosystems there are two groups of woody plants. Trees that reach high for the light and shrubs that grow under the trees. Ecologists call the trees the upper story and the shrubs the lower story. Since you have completed the upper story at the transect point, now repeat the process only this time work with the shrubs. You may have some difficulty in determining if the plant is a tree or a shrub. All ecologists have this same problem so you will have to make the decision. Record the distance from the stake to the nearest shrub. Record this information in column (6) of the data sheet. Now identify the shrub using the key and record the name of the shrub in column (5).

7. Measure the distance from the shrub you just identified to its nearest neighbor. Record this information in column (8). Identify the shrub and record the name in column (7).

8. Now move to the next stake and repeat the operation. Do this until you have data for the ten transect points.

EXAMPLE

Tran. Pt.	1. Stake Species	2. Dist. in M.	3. Neighbor Species	4. Dist. in M.	5. Stake Species	6. Dist. in M.	7. Neighbor Species	8. Dist. in M.
1	Thin Leaf Alder	1.5	Water Birch	1.0	Common Juniper	0.0	Nootka Rose	0.5
2	Plains Cottonwood	1.0	Thin Leaf Alder	0.5	Bebb Willow	0.25	Redshoot Gooseberry	0.5
3	Quaking Aspen	0.5	Quaking Aspen	0.5	Snow-Berry	0.0	Nine-bark	0.25
4								
5								
6								
7								
8								
9								
10								

9. On the second page of your data sheet, write the name of the ecosystem that corresponds to the stake number.

10. On the second page of your data sheet write down three relationsheips you observed between the shrubs and trees.

11. On the second page of your data sheet, formulate a hypothesis, why the ecosystems change along the transect.

NEAREST NEIGHBOR DATA SHEET

Transect Point	Trees				Shrubs			
	Stake Species	Distance in meters	Neighbor Specie	Distance in meters	Stake Species	Distance in meters	Neighbor Specie	Distance in meters
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
Column	1	2	3	4	5	6	7	8

Transect Point	Ecosystem
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Three relationships you observed between the trees and shrubs along your transect.

1. ____________________

2. ____________________

3. ____________________

Your Hypothesis:

____

____

AQUATIC ECOLOGY UNIT

Exercise I: The Jug

Ecology is the study of the relationships between plants, animals and the non-living things in an area. These areas may be very large to very small, and we call these areas ecosystems. We can divide the ecosystem into the living parts, which is called the biotic and the non-living parts which is called the abiotic (a-without----biotic-life). In this unit you will identify the various parts of your ecosystem and determine how they influence one another.

Objectives

1. You will construct an aquatic ecosystem.

The Experiment:

1. Locate a one gallon wide mouth jar. This jar may either be plastic or glass. The most common used jugs are the one gallon salad dressing jars.

2. Now select the water for your jug. This is the most important part of this unit. Everything that will happen in your ecosystem will depend on the quality of water that you select. How does one go about selecting water for one's jug? The best advise that I can give is find a pond or stream of water that is just loaded with little critters. I have seen some students bring in water and after two months they still didn't have one little creature in their ecosystem. Fill the jug up to the neck with water.

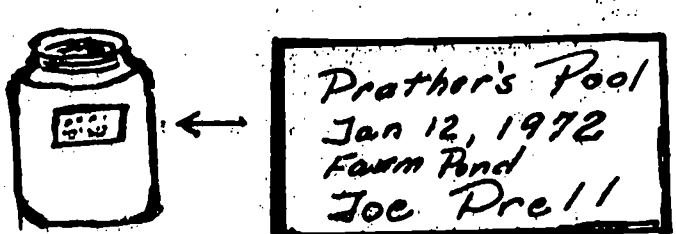
3. If you should happen to collect some aquatic plants and animals living in your water source, so much the better.

4. Just as important as the water is the mud that you will place at the bottom of your jug. This layer will be called the ooze layer. The ooze layer is very important in your ecosystem. About 1-2 cm of mud at the bottom of the jug is needed. Be sure and get the mud for the bottom of your jug from the same body of water that you collected your water sample.

5. Bring your jug, water, ooze and critters to school. Place the jug under the light source. Draw a line, using a grease pencil, at the water level in your jug.

6. An important aspect of ecology is recording data. Name your ecosystem. On a label put the name of your ecosystem, the date you collected the water, location where the water was collected and the name of the the famous ecologist doing the study. If you have trouble spelling ask your teacher for help. Don't feel bad if you have trouble spelling because I know a whole bunch of ecologists that can not spell for beans.

7. And away we go!



Exercise II: Succession in the Jug

Ecosystems are dynamic. This means that they are always in a state of change. These changes are directional and can be predicted. Sometimes these changes are very slow and other times they go like mad. In order to determine the quantitative and qualitative changes that take place you will have to develop great skill in observation.

Objectives:

1. You will identify the organisms in your pond using Exercise II Key.

2. You will count the organisms in the ecosystem by subsampling.

3. You will record the data collected in this exercise.

The Experiment:

1. Now that you are an ecologist, you will start sampling the abiotic and biotic parts of your ecosystem. This must be done at regular intervals. A suggestion would be to conduct your counts twice a week. Sometimes this will get monotonous since the changes may be very slow. Watch out! All of a sudden things will really start jumping. The only way one can find out when these changes take place is to make these regular counts.

2. Every week check the water level in your jug. Make sure that it is up to the waterline. Record the number of ml of water that you added to bring it up to the water line. When your jug is low fill it with the water from the big jug that is for filling low jugs.

3. When you start your critter counts you will see that the organisms fall into two groups. The first group we will call macroscopic organisms or those that you can see with the naked eye. The second group will be called microscopic because you must use a microscope to see them.

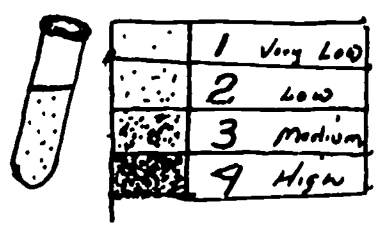
4. Macroscopic organism counts. Macroscopic organisms in your ecosystem will seldom reach high numbers. The easiest method is just count them all. Be careful because not all of the macroscopic organisms are the same. When you start your count, catch the organism without hurting him. Place him under the scope and with the aid of the Organism Key find out who he is. Now look at the data sheet and you will find a section called macroscopic animals. In one of the columns write the name of the animal and below write in the number of that type of organism found in your jug. Make sure you return the organism back to the jug.

5. Microscopic organism counts. Counting the little organisms is much more difficult than the big ones. First let's learn how to collect them. At the ecology center you will find glass tubes with numbers written along the side. These glass tubes are called pipettes (pie pets). There is a trick to using a pipette. Suck the water up the glass tube just like you suck coke up a straw. When you reach the level you want, put your tongue over the end. Now quickly replace the tounge with a finger. Try this several times using water from a tap. Now let your finger off so the bottom of the curve reaches the line on the pipette. Remember when you start using the water from your ecosystem if you haven't practiced you may get a mouth full of slough water, loaded with little bugs. Anyone for lunch?

6. Collect a 10 ml sample from your jug. Pipette the water and little organisms in a watch glass. Put the watch glass under the scope and identify the organisms using the key. Take your time. Just count the animals. Count each group of organisms separately.

7. Write the name of the microscopic organism at the top of a column and under it write the date in the left column and the number of organism under the proper column of the data sheet.

8. You will see several different kinds of green plants in your pond. These are called algae. Algae is difficult to count because they are so small. We will use the color of the water as a quantitative value for the number of algae cells present in the water. Take the small test tube and fill it with water from your jug. Now take the color code algae card and hold it up beside your tube. Now compare the color of your tube with the card. When you find the closest color to your tube water color, check the number of the card color and record this in the proper column of your data sheet.



9. Calculating the amount of algae in your jug using the method of #8 isn't very quantitative and the changes are very slow. We are going to try something new. There is a little plant called duck weed that is very common around Billings. There is a relationship between the rate that these grow and multiply and the amount of algae present in the water. From the duck weed supply container, take five duck weeds and place them in your ecosystem. If you have duckweed in your ecosystem make sure there are only five. The surplus should be put in the duckweed holding pond. Now record in the proper column the figure five. Each time you sample your pond count the number of duckweeds present.

10. You have your work cut out for you now. If you have trouble ask your teacher for a hand so you get started correctly.

11. After you have taken your first sample, take your data sheet to the teacher for approval. If something is wrong, it's back to the old drawing board.

12. Each week get your teachers approval.

13. Now start the next exercise.

Data Sheet

Succession in the Jug

Date	Plants		Number of Organisms							
	Duck Weed	Algae Color Code	Macroscopic Animals				Microscopic Animals			

KEY

TO THE

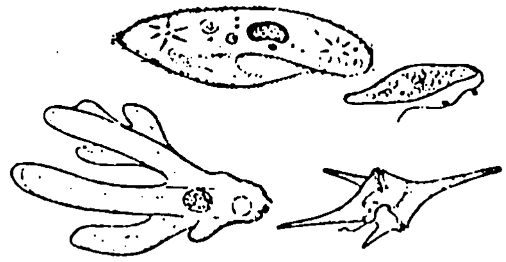
JUG

ORGANISMS

1a. Body of the animal is one celled, so small it can only be seen through a microscope.

PROTOZOA

Protozoa are very common in water. There are many different kinds of protozoa. Since they are very difficult to tell apart, for your jug study we will lump them all together.



PROTOZOA

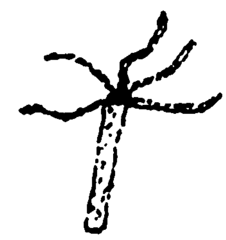
1b. Body of the animal multicellular, macroscopic, visible to the naked eye. (2)

2a. Body has equal right and left halves, like your body, or bilateral symmetry. (3)

2b. Body has radial symmetry, or is in the design of a circle. (Note the arms are all radial.)

HYDRA

This little animal clings to the side of your jug or the vegetation growing in your jug. All hydra have minute stinging cells called nematocysts. Each nematocyst contains a coiled string and a barbed spear at the end.

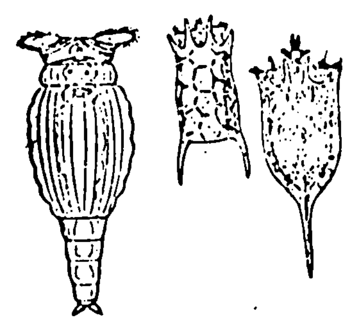


HYDRA

3a. Animals will have several terminal tufts of large cilia or one or two rings of cilia at anterior end.

ROTIFERS

Most of these animals will be found swimming around or attached to leaves and mud. The cilia on the ends of these animals look like wheels that are spinning. The cilia are used for moving and collecting food.



ROTIFERS

3b. Animals will not have any terminal cilia sweepint around anterior end. (4)

4a. Animal has a single shell which is usually coiled.

SNAILS

These shelled animals are found crawling on vegetation or hiding in their shells. The part that extends out of the shell is called the "foot". The head end has a pair of tentacles. The snail moves on a "slime track" of mucous when it crawls.

ROTIFERS

4b. Animal has no shell. (5)

5a. Animal long and slender, worm-like. (6)

5b. Body of animal not worm-like. (9)

6a. Worm is thin and long, and is always in a moving, whip-like action.

NEMATODES

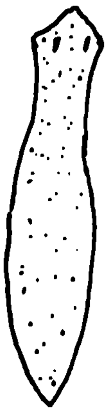
NEMATODES

These are the roundworms. They will be found in soil and water on the bottom of your jug. The whip-like motion makes it hard to study them. They eat the dead plant or animal material found in mud. These animals are found in more different kinds of habitats than most any other animal.

6b. Organism does not fit above description. (7)

7a. Animals body is divided into segments. (8)

7b. Animals body is not divided into segments, body is flattened.

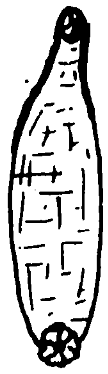


FLATWORMS

FLATWORMS

These worms hide under rocks and debris. They eat other little animals dead or alive. They may be covered with cilia for moving, or they may move on mucous like the snail.

8a. There are large sucker-like disks on the animals anterior and posterior ends.

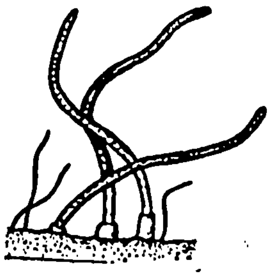


LEECHES

LEECHES

These animals live in mud at the bottom of your jug. Their body is divided into many segments. Their mouth is in the anterior sucker. They have eyes, either simple, that appear as dots, or compound eyes that appear as a cluster of dots.

8b. Animal with no sucker-like disks. (9)



TUBIFEX

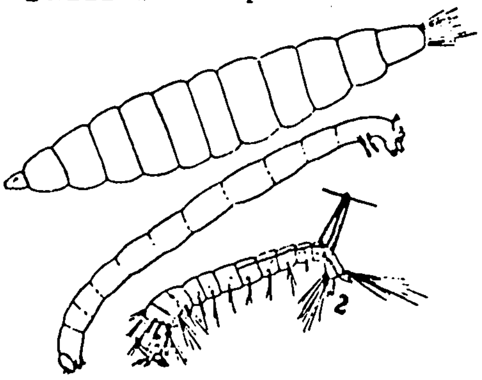
TUBIFEX

This worm will put its head end into mud and wave the posterior end in the water to breath. He is found often in polluted water, often in large numbers.

9a. Animal reddish in color, four setae (long hairs) per segment.

DIPTERA

These are the larvae of insects commonly found in water. Mo quitos are Diptera. At the bottom of your jug you will find another type of Diptera larvae (the immature stage of this insect.) Many of these have no distinct head or legs.



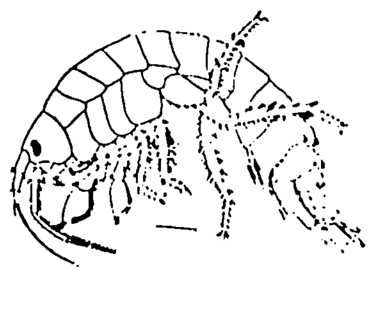
DIPTERA

9b. Animal not reddish in color, setae usually lacking, if present they are at the end of the organism. (10)

10a. All body segments but the last one have appendages.

GAMMARUS

These are small, shrimp-like animals found in unpolluted water. During daytime they hide under stones and vegetation. They move by crawling and walking. When they swim, they often roll over on their side or back.



GAMMARUS

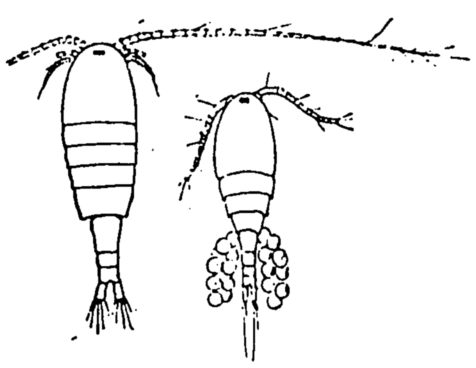
10b. Animal does not fit above description (11)

11a. Body of animal is covered by a thin shell or carapace (12)

11b. Body of animal not covered by a thin shell. Head end does not appear to be segmented, but abdomen is plainly segmented.

COPEPOD

These will be found swimming with their antennae. They also can crawl on mud. They filter water to eat the plankton in it. They can live in polluted water with less oxygen in it than Cladocera.

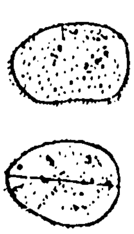


COPEPOD

12a. Body of animal is entirely covered with a thin shell; animal has two pairs of body appendages.

ASTRACOD

These animals resemble small seeds, and are called "seed shrimps". They are found living in mud, or swimming above it. They are scavengers, eat dead and decaying matter that is strained by its front legs. These animals do not appear in grossly polluted water.

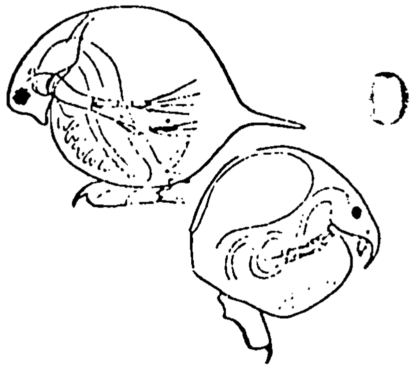


ASTRACOD

12b. A thin shell covers the body of the animal, but not the head of the animal. It has 4 to 6 pairs of body appendages.

CLADOCERA

These animals are called "water fleas". Some have a posterior spine sticking out from their shell. They swom with their antennae and eat by filtering food particles out of the water. They like fresh water habitats.



CLADOCERA

Exercise III: Physical Changes in the Jug

The abiotic factors play an important role in the ecology of any ecosystem. The abiotic factors are divided into the physical and chemical properties. Perhaps the most important physical parameter is temperature. All plants and animals have temperature limits. Some have broad limits while other organisms have very narrow limits. For example, you can run stark naked outside from your warm classroom over the snow and back without too many harmful effects. The only thing that might happen is that your teacher would get up tight and kick you out of school for a few days. If you were a little critter in a jug you would not be able to adjust to a wide temperature change. Certain organism live in cold water while a different group will live in water at room temperature.

Evaporation is also going to play an important role in your jug and it is also classed as a physical parameter.

OBJECTIVES:

1. You will measure and record on your data sheet the daily temperature within your ecosystem.

2. You will measure and record the amount of evaporation of water from your jug.

3. You will calculate the amount of heat lost from your jug through evaporation.

The Experiment:

1. Each day, at the same time, take a thermometer from the environmental center and measure the temperature in your jug. Record this temperature on your data sheet.

2. At the same time as you measure the temperature of the water in your jug, also measure the record on the data sheet the room temperature.

3. Each day observe the water level in your jug. When the water level drops below the black line you drew at the original water level in the jug, add water from the water replacement jug in the environmental center. Using a pipette, measure the number of milliliters (ml) of replacement water is required to bring the level to the black line. Record this information on your data sheet.

4. How much energy is required to evaporate the water from the jub? Scientists have calculated that it required 580 calories of heat to evaporate 1 ml of water at room temperature. We can determine the amount of heat that is lost from the water in your jug by multiplying the ml of water evaporated times 580. This physical property of water is going to be very important when we do the stream study at Camp.

ml of water X 580 = calories of heat lost from the jug

Physical Properties of the Jug

Date	Room Temperature	Jug Temperature	ml of H_2O added	Calories of Heat Lost

Exercise IV: Chemical properties of the jug water

An ecologist can tell you many things about an ecosystem by running a series of chemical tests on the water. The physical properties of the water will tell the ecologist organisms that might be present. Chemical properties will also determine the organisms that will be present but also indicate the number of organisms present. Since these chemicals provide the needed nutrients for the ecosystem, you can see how a lack of these nutrients could limit the number of organisms present.

Objectives:

1. You will measure and record on your data sheet the amount of oxygen present in your ecosystem at weekly intervals.

2. You will measure and record on your data sheet the alkalinity present in your ecosystem at weekly intervals.

3. You will measure and record on your data sheet the pH of the water in your ecosystem at weekly intervals.

4. You will interpret the chemical properties of your jug and compare it to the other jugs in your classroom.

The Experiment:

1. We are all aware how important oxygen is for growth of plans and animals. An aquatic environment is very different from a terrestrial or land environment with respect to oxygen. In a terrestrial environment the oxygen makes up 21% of the air around us but in water the amount of oxygen is only a fraction of this percentage. Therefore instead of measuring the percent of oxygen in water it must be measured in parts per million (ppm) by weight. For you students doing these experiments, it is just another measurement like meters, grams, and liters. At the end of this exercise you will find "The Guide for Water Chemistry". Follow the directions carefully. After you have run the oxygen test, record your findings on the data sheet.

2. Next you will test the alkalinity in the water. In this case you are testing for the amount of calcium bicarbonate present in the water. The chemical formula for calcium bicarbonate is $Ca(HCO_3)$. The reason that this chemical is so important in an aquatic ecosystem is that it provides the CO_2 which is needed by the plants. If there is little or no CO_2 available for the plants what will happen to the number of plants in your jug? Again, turn to "The Guide for Water Chemistry" and run the test for alkalinity. After you have run the alkalinity test, record your findings on the data sheet.

3. You will also determine the pH of the water. A pH test can also be used as an indicator as to the quality of the environment. The method on how to determine the pH is found in "The Guide for Water Chemistry". After you have run this test record your findings on the data sheet.

4. After you have completed this series of tests three times draw conclusions from your data based on the information given in "The Guide for Water Chemistry". When you have completed this exericse turn in to your teacher the data sheets and your conclusion sheet.

Chemical Properties

Date	Oxygen	Alkalinity	pH

Chemical evaluation of your jug based on "The Guide for Water Chemistry".

GUIDE

for

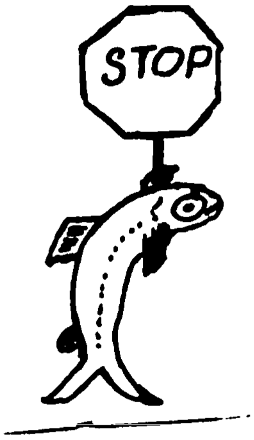
WATER

CHEMISTRY

Guide for Water Chemistry

OXYGEN DETERMINATION

1. Fill the bottle marked DO (dissolved oxygen) bottle with water from your jug

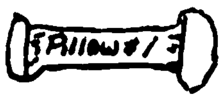


TEDDY THE TROUT "says"

Make sure the DO bottle is clean.

2. Be certain there are no air bubbles present in the bottle.

Psst...............To keep from getting air bubbles-tip the bottle to one side and quickly stick in the stopper.

3. Remove the stopper and pour in 

\+ 

4. Insert the stopper to keep air from getting in.

5. Shake the bottle and mix the chemicals and water It should turn a brownish color. Let the small pieces (floc) that are floating around in the bottle settle.

6. Now-----------take off the stopper and open up and pour in 

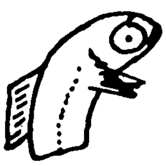
7. Put the stopper in and shake up to mix The small pieces will dissolve and the water will be a yellow color if oxygen is present

8. Fill the plastic measuring tube with the prepared sample from the DO bottle and pour into the mixing bottle.

9. Holding the dropper  straight up add drops of PAO solution to the mixing bottle.

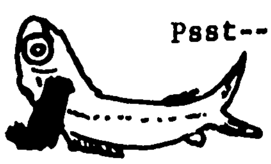
10. Count the drops of PAO until the sample changes from yellow to colorless

-OXYGEN-



Psst-------Don't leave the PAO solution in direct sunlight because it will be ruined.

The ppm dissolved oxygen is equal to the number of drops used.



Psst-------Don't mix the chemical and clean up the glassware after you are done.

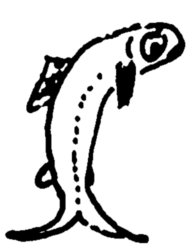
* *

Jim Poz from the Fish and Game Department says ---------

0 to 2 ppm dissolved oxygen	--	means you have a highly polluted aquatic environment or a winter kill situation
3 to 4 ppm dissolved oxygen	--	carp, bullheads, and some warm water fish, such as sunfish and crappies can live in this water
5 to 15 ppm dissolved oxygen	--	This is trout water. It also means that there is very little pollution in the water.
0 to 15 ppm dissolved oxygen	--	High oxygen readings like these are usually only found in fast moving mountain streams where the air is being continually mixed in the water.

ALKALINITY DETERMINATION

1. In the environmental center you will find the chemicals and glassware needed to do this test.



..... STOP

Make sure the glassware is clean

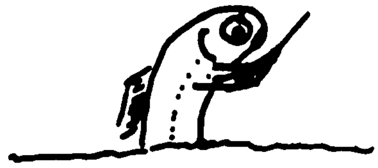
2. Fill the plastic measuring tube full of water from your jug and pour into the mixing bottle.

-ALKALINITY-

3. Add the contents of one Brom Cresol Green-Methyl Red Indicator Powder Pillow in the mixing bottle.

4. Now the solution should be a green color.

5. Add the Alkalinity Sulfuric Acid drop by drop. Swirl the mixing bottle as you add the drops. REMEMBER --- count the drops as you mix.



6. Continue to do this until the color changes from green to pink.

7. The total alkalinity = the number of drops of Alkalinity Sulfuric Acid x 17.

* *

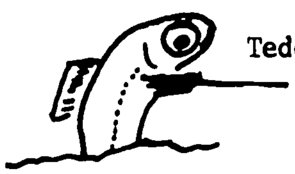
Jim Poz says ------------

0 to 99 ppm alkalinity	--	low alkalinity and usually the fish populations will be low. This range of alkalinities are usually found in the high mountain lakes found in granite formations. These lakes will appear to be blue when viewed at a distance.
100 to 180 ppm alkalinity	--	These are usually productive lakes found in the area of limestone formations. Instead of appearing blue as the previous group of lakes, these will have a green tint.
181 - 300 ppm alkalinity	--	These lakes are found in eastern Montana where the lakes have no stream or many of the farm ponds found in this area. These are highly alkaline waters and very productive. Sometimes there is so much life living in the water that at night they use most of the oxygen in the water. Another place that you may find these high alkalinity waters is some of the large springs that come up in eastern Montana. A good example is Bluewater Creek near Bridger, Montana.

pH DETERMINATION

1. In the environmental center you will find the chemicals and glassware needed to do this test.

2. Fill the two glass pH sample measuring tubes.

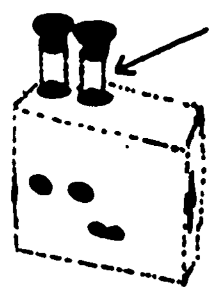


Teddy says ----- be sure the tube is labeled pH.

3. Fill the pH measuring tubes to the mark near the top of the tube with water from your sample.

4. Add 6 drops of pH indicator to <u>one</u> of the tubes and swirl to mix.

5. Put the tube with the indicator solution in the opening nearest the middle of the pH measuring device.



6. Put the other tube of water without the pH indicator in the outside opening of the pH measurer.

7. Hold the pH measurer up to a light or sky so the light comes through the two holes in the side of the pH measurer.

8. Turn the color disc until the color of the wheel matches the tube with the pH indicator.

9. Read the pH from the scale on the disc.

Poz says ---------

6.0 - 6.8 pH	This is a low pH and indicates either the water is polluted with some type of industrial or mining waste or the stream or lake water contains only small amounts of dissolved minerals.
6.9 - 7.5	These ranges are common in many Montana lakes and streams. Once again it indicates that the mineral content of the water is low.
7.6 - 8.5	This is a high pH and indicates that the stream has an abundant supply of dissolved minerals, including $Ca(HCO_3)_2$.

PLOT STUDY UNIT

Introduction to this Unit

Any piece of ground is an environment for certain kinds of plants and animals, and it has various physical and chemical characteristics that determine what plants and what animals live there. In this unit (combining numbers 100 through 114) you will find out how to measure many characteristics of any piece of land. These skills can then be applied to the areas studied in the Plant Ecology Unit. When the data from the Plant Ecology Unit on changes of the plant life and the data showing the physical and chemical nature of each plant station are combined, you should be able to see fundamental relationships between them. From these, you then can predict some of the characteristics of an area from observing the plants, or be able to predict the kinds of plants an area would have if you know some of the key physical and chemical characteristics. In addition, once you understand land characteristics, you can intelligently decide when, where, and how we can use land without abusing it.

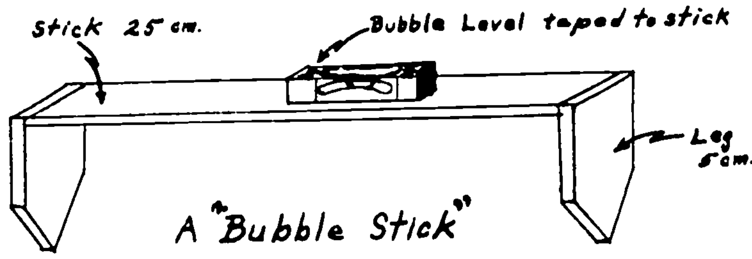
Instructions:

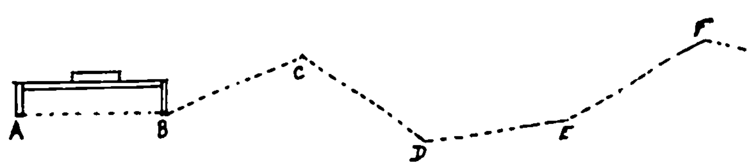
The information and directions given in Skills #101 through Skill #114 will prepare you to be able to completely map and analyse a small plot of ground. Those skills can also be applied separately to investigate any land environment.

Study the directions carefully. Learn how to make the measurement. Learn how to calculate the final value in those few where calculation is needed. And get in the habit of recording the data.

In working on these skills, having a partner often helps, for you can check and correct each other and help each other learn.

CONTOUR LINES





Objectives:

1. to be able to lay out a contour line on an uneven piece of ground.

2. to understand what a contour line on a topographic map means.

Materials:

One straight stiff stick, about the width of a ruler, and about 25 cm long. A ruler itself is all right to use. (The length is not important, but the shorter the stick, the more accurate will be the contour line.) To each end of the stick glue or nail a small leg about 5 cm long. To the top of the stick, in the middle, tape on a small bubble level. (See diagram) Also, you will need two 2-meter pieces of string and 12 small stakes, such as tongue depressors or flower pot label sticks.

Definition:

A contour line on a map is a line connecting points of equal elevation.

The Idea:

If a contour line on a map is a line connecting points of equal elevation, the map-maker must have climbed around the hills and determined the elevations of a great number of separate points. He plots and locates on his map those points of equal elevation above sea level, then draws a line connecting those points. The resulting line on the map is a contour line. But a map has many contour lines and they are separated by a "contour interval". You'll learn about contour intervals in Skill #102. For now, let's concentrate on learning how to stake out a single contour line.

What to do:

1. On an irregular piece of ground, put in a stake anywhere and call it point A. This is the starting point.

2. Put one leg of the bubble stick at A. With one leg fixed at A, move the other leg to different spots until a spot is found that makes the bubble in the level be at the center of the level. Mark that point on the ground with a stake labeled B.

3. Now move the bubble stick so that B is the starting point. With one leg at B, move the ruler until the other leg finds a point that causes the bubble to be centered. Mark this point C.

4. Continue for as many points as are needed or wanted. For this practice session, mark 3 points to the right of A, then go back to A and mark 3 points to the left of A.

5. Lay a string on the ground from A to B to C, and so on. The string now represents a contour line.

6. Now stand above the string, and get an airplane view of it. On the bottom of this sheet, using a scale such as 2 cm to represent the length of the stick, accurately mark the locations of the stakes, then connect those points.

7. Next, get down on your hands and knees, and get your eyes at the same height as the string. From that position the string should appear to be a straight line.

8. You and your partner should each make two different contour lines at least 2 meters long, and draw them on a sheet of paper. If you can do this well and accurately, you are on your way to becoming map-makers.

<u>Data Sheet</u>

Draw here, to a scale of 1 meter = 20 cm, a top or airplane view of the contour lines you and your partner staked out. When you got your eyes close to the ground and at the same level as your contour lines, did they all look like straight lines?

CONTOUR INTERVAL

Objective:

1. to be able to measure the total change of elevation on a plot of ground.

2. to then be able to decide on a convenient contour interval suitable for a particular map.

Materials:

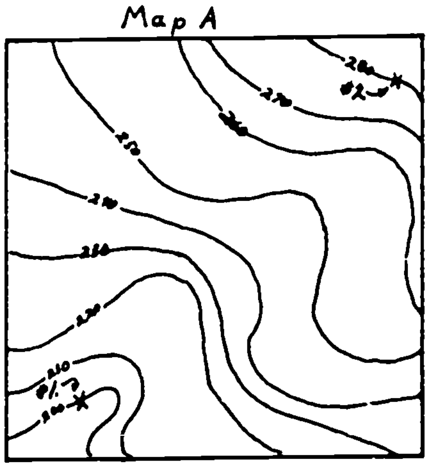
One straight stick about 25 cm long with a bubble level taped to it -- like the one used for Skill #101, but without the legs. One meter stick or ruler. One piece of string 4 meters long. Another piece of string about 1½ meters long. And 12 small stakes.

Definition:

A contour interval is the vertical distance between contour lines on a particular map.

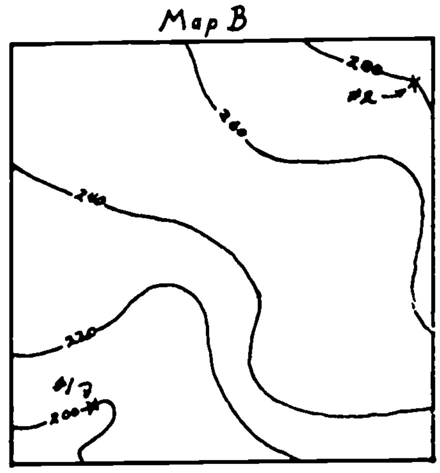
The Idea:

Map A



Contour Interval = 10 ft

Map B



Contour Interval = 20 ft.

Here are small pieces of two contour maps drawn to the same horizontal scale. Each map represents one square mile. But Map A states at the bottom, "Contour interval 10 ft," and Map B states "Contour interval 20 ft." Remember what you learned in Skill #101 about contour lines. Study these two maps. Is it true that the closer the contour lines are, the steeper is the land? ______. Is this true for both maps? ______.

Which way is up hill? If you hiked from #1 to #2 on the land shown by Map A, how many vertical feet would you climb? ______. How many vertical feet would you climb from #1 to #2 on the land shown by Map B? ______. Do you see that contour lines on a map do not by themselves tell you how steep the land is unless you know how much vertical distance is climbed between contour lines? Do you see, then, that for any map showing contour lines we must know the contour interval?

What to do:

A. Locate the highest and lowest spots.

1. Select a piece of uneven, sloping ground about one meter by one meter. Stake the four corners, and run the 4 meter string around it to clearly mark the area.

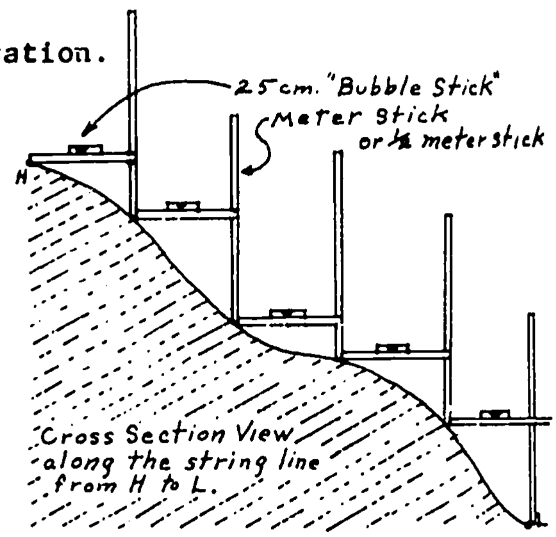
2. Put a stake labelled H at what you judge to be the highest point.

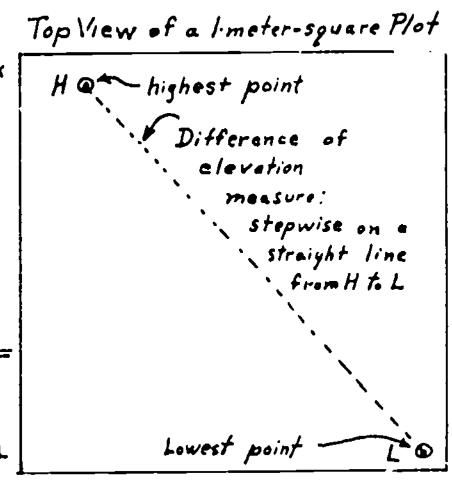
3. Put a stake labelled L at what you judge to be the lowest point. It's quite possible if your plot is on top of a hill or mound, H may be in the middle and not at one edge. Or if your plot is at the bottom of a gully, L may be in the middle. But wherever they occur, stake H and L.

4. Run the $1\frac{1}{2}$ meter string from H to L. Your job now is to measure the <u>change</u> in elevation from H to L.

B. Measure the change in elevation.

1. Starting at H, place one end of the bubble stick at H and the other pointing towards L. Raise or lower the free end of the stick until the bubble shows the stick is level. With the meter stick, measure the distance from the free end of the bubble stick to the ground. Record this value as the Step 1 on the Data Sheet at the end of this writeup. Place a stake at the point where the vertical meter stick hit the ground at 1 .





2. Move the bubble stick so that one end is now at 1 , and so that the bubble stick is pointing towards L. Make the stick level, and with the meter stick measure the vertical distance from the free end to the ground. Record this value, and put in a stake 2 at the base of the meter stick.

3. Continue to "stair-step" from H to L. The last stair may be short of the free end of the bubble stick, but just place the meter stick at L, hold it vertically, and read the vertical height. Record it.

4. The sum of the several vertical measurements is the total change of elevation between H and L. Now pull out those stakes, but leave H and L and the corners.

C. Determine a suitable contour interval.

For a small 1 meter by 1 meter plot, 3 or 4 contour lines will usually be adequate. But remember that the more contour lines you make, the more accurate is your map.

1. Let N be the number of contour lines you want on your plot.

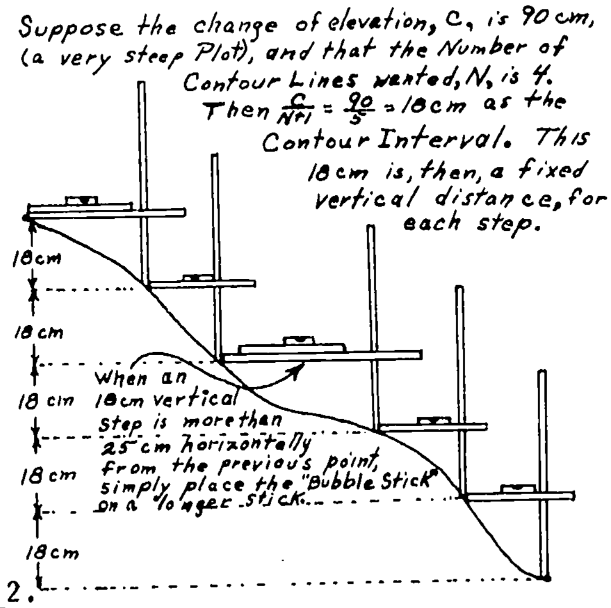
2. Let C be the change in elevation from H to L.

3. The contour interval will be $\frac{C}{n + 1}$.

D. Use the contour interval

Now that you have a contour interval, you must locate <u>one</u> point for each contour line.

1. Place one end of the bubble stick at H, with the stick pointing towards L.



2. Raise or lower the bubble stick until it is level.

3. Put a thumb on the meter stick at the value of the contour interval. Hold the meter stick vertically, with your thumb touching the underside of the horizontal bubble stick. Slide the meter stick along the bubble stick (keep the meter stick vertical and the bubble stick horizontal) until the bottom end of the meter stick touches the ground. Put a stake there labelled line 1. This now becomes the starting point for the highest contour line.

4. Now move the bubble stick to the line 1 stake, and in the same manner as you just did, locate a point that is one contour interval below the line 1 stake. Label this next point line 2.

5. In the same way, locate one stake for each of the other planned contour lines. If you've done this whole thing carefully, the vertical distance from the lowest contour line stake to point L should be one contour interval.

Data Sheet for #102 --- Contour Interval

Vertical measurements of steps from H to L ---

Step 1 =
Step 2 =
Step 3 =
Step 4 =
Step 5 =

Total =

or change of elevation from H to L. THIS IS C.

Number of contour lines desired in your plot _____. (You decide this.) Then this number becomes N.

Contour interval = $\frac{C}{N+1}$ = ______ = $\boxed{}$ your contour interval

1. On this map of your 1 meter by 1 meter plot, locate and mark H and L.

2. After you have located and staked the starting points for each contour line on the ground, mark those stakes on this map.

3. Just for practice, construct on the ground (see Skill #101) a couple of the contour lines and mark them on this map.

(Scale: 1 Meter = 10 cm.)

SLOPE

Objective:

1. to be able to determine the slope of land.

Materials:

One 25 cm stick with a bubble level taped to it.
One meter stick, or ruler marked in centimeters.
If these are not available, use two rulers.

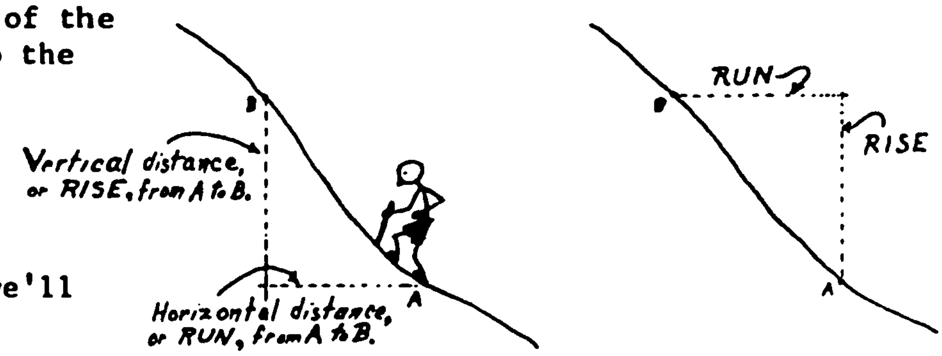
Definition:

The Slope of land is the ratio of the vertical distance (or the Rise) to the horizontal distance (or the Run),

$$\text{or Slope} = \frac{\text{Rise}}{\text{Run}}$$

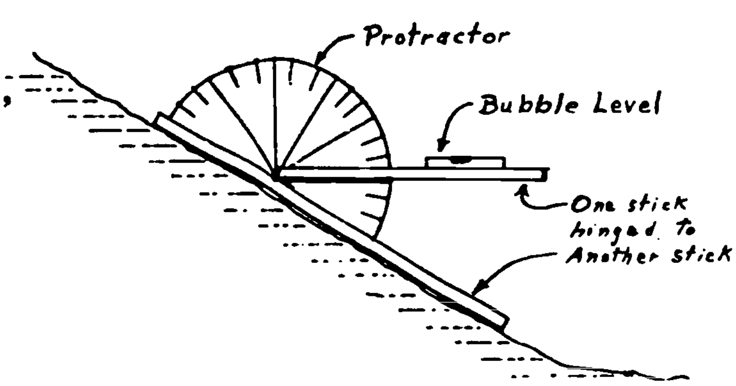
Usually slope is expressed as a percentage. In this Skill Sheet we'll do that, and so

$$\text{Percent of Slope} = \frac{\text{Rise}}{\text{Run}} \times 100.$$



The Idea:

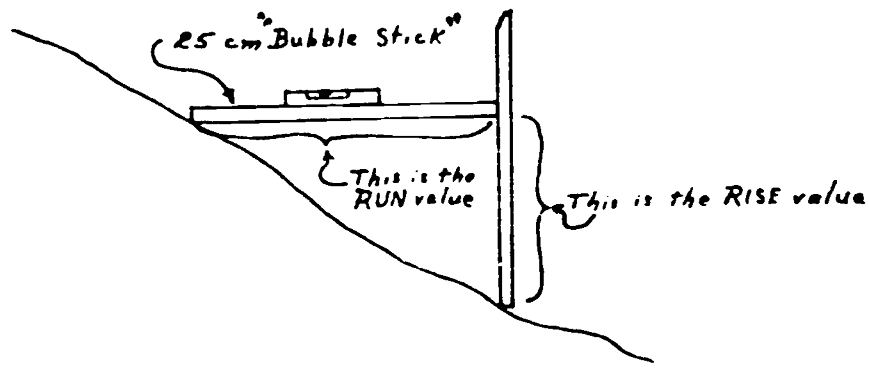
How steep is a steep hill? What may be steep to an old lady in a wheelchair may not seem at all steep to active young people. And what seems steep to you would be nothing at all to a Mountain Goat. Evidently we need a way of accurately describing steepness. We could describe it as an angle measurement, and a simple device such as the one shown here would work fine. We also could define it as stated above for Slope, and this is the way most engineers, soil scientists, and land managers define steepness.



The slope of land is important to know whenever a person is going to use land for almost any purpose. In far too many cases, ignorance of or blindness to the significance of slope has resulted in a great damage not only to the land there but to downhill areas.

What to do: (see diagram on the next page.)

1. Place the bubble stick with one end touching the ground. Raise or lower the free end until the bubble tells you the stick is horizontal. This 25 cm stick is the Run.



2. Hold the meter stick vertically. Rest one end (the zero end) on the ground, and have the meter stick touch the bubble stick.

3. Read the meter stick at the point where the bottom of the bubble stick touches it when the bubble stick is level. This number is the Rise.

4. Calculate the percent of slope (see definition).

(Some precautions): Any length of bubble stick can be used, but if its length (in whatever units you use) can be divided easily into 100, the arithmetic is easy. You could use 20 cm, 10 inches, 25 cm, 50 cm, 10 ft, or any other length that readily divides into 100. In addition, the length of the vertical stick does not matter, provided it is long enough to reach the bubble stick and provided that its unit of measurement is the same as that of the bubble stick. Don't try to mix inches and centimeters. You'll find the metric unit (the centimeter) is much more convenient to use than are inches or feet.

5. You and your partner should each make 5 slope measurements. In the data columns below record the Rise and Run values of each, and then record the percent of slope of each after calculating it.

Data Sheet: State unit of measurement for each. Try various units and lengths of Run, but be sure that for any one measurement both Rise and Run are the same unit.

	Partner #1			Partner #2		
	Rise	Run	% Slope	Rise	Run	% Slope
Slope A						
Slope B						
Slope C						
Slope D						
Slope E						

Follow up:

1. On the bottom or back of this page, list at least five examples of slopes where damage has occurred or can occur, and state what sort of damage it is.

2. For each of the cases you cite, what could have been done to prevent the damage.

3. What is the general slope of the ground on which your house or apartment building is built? Are there any problems there as a result of the slope?

4. What is the slope of a hill on which a school bus, your dad's car, or a truck goes into a lower gear?

5. What is the least slope of ground on which water will erode soil? Does it make a difference what kind of soil it is?

COMPACTNESS MEASUREMENT

Objective:

1. to be able to measure the compactness of ground.

Materials:

One wooden dowel rod, about the thickness of a pencil, with one end sharpened in a pencil sharpener and the other end cut off squarely.

One ruler.

Definition:

The measurement of the compactness of ground reflects how tightly packed are the soil particles.

The Idea:

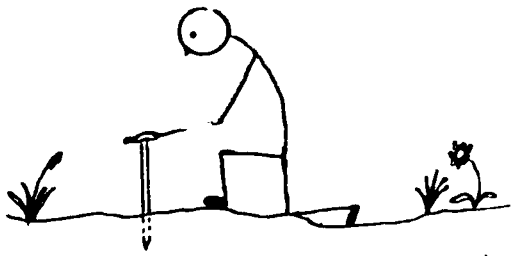
You know from experience that not all ground is equally hard or equally soft. You know that it is much easier to drive a stick into a loose sandy soil than into a heavy clay soil. In the same way, water and air (both of which are needed by plant roots) will enter a loose soil more easily than a tight, dense soil. This compaction test gives a simple measurement of this important physical quality of soil.

What to do:

1. Place the square end of the rod into the middle of the palm of your hand.

2. Place the sharpened end on the ground.

3. Push the dowel into the ground until it hurts -- until you just don't want to push any more. This "thresh-hold of pain" represents a certain force which will be different for each person.



4. Put your thumb on the dowel at ground level, and pull the rod out of the ground.

5. Measure on the rod how far it had been pushed into the ground. Record this value.

6. Perform this measurement in various places, as suggested on the data sheet. Your measurements and your partner's measurements probably will not agree, but that doesn't matter. The general relation of measurements should agree, however. That is, if in one spot you get 5 cm and your partner gets 7 cm, and in another spot you get 10 cm, then your partner should get 14 cm.

Data Sheet (State unit of measurement)

Location of test	Partner #1	Partner #2
In a dirt pathway		
In a lawn		
Under a bush		
In a dirt road		
Other locations:		

Follow up:

1. Can you show, by compactness measurements, why a dirt pathway erodes but the lawn beside it does not?

2. Why doesn't grass grow in a dirt pathway? Does the grass that was there simply get worn off, or have soil conditions changed so that grass can't grow in the pathway?

3. What can be done to get grass to grow in such a pathway?

4. What happens to the soil (and the plants) in a playground? In a park? In a campground?

WATER INFILTRATION RATE

Objective:

1. to be able to measure the water infiltration rate of various soils.

Materials:

A tin can (such as a #5 juice can) with both top and bottom removed, and the bead or lip on one end cut off with tin shears to make a cutting edge.

A jar of water (about 1 liter or 1 quart).

A watch with a sweep second hand.

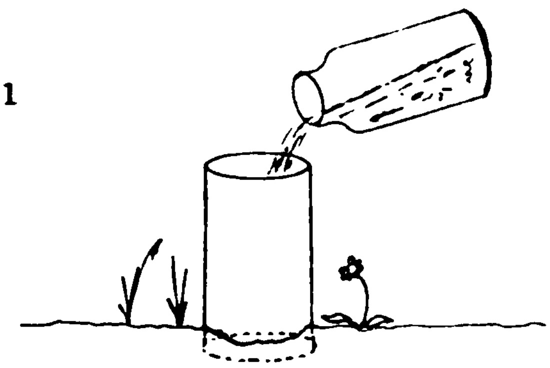
Definition:

The term Water Infiltration Rate refers to the rate at which water goes into the ground.

The Idea:

Water, when it falls to earth in any form, has only three paths it can follow -- (1) it can be evaporated at once, or (2) it can run on the surface of the ground, or (3) it can soak into the ground. A major effort in all soil and water conservation efforts is to increase the amount of water that soaks into the ground and to decrease the amount that runs on the surface. Which direction (into or on the soil) the major amount of water takes depends absolutely on the quality and nature of the soil. And a measurement of the water infiltration rate is a significant piece of information about the particular environment being studied. Such a measurement gives information on how that environment acts towards water -- and this in turn has a lot to do with determining the kinds of plant and animal life there, or the kinds of uses to which man can put that land.

What to do:



1. On any piece of ground, twist the can into the soil (sharp edge of can must be down). Be sure that the can cuts through any surface vegetation or litter and becomes anchored about 2 cm deep in mineral soil.

2. Pour in the liter of water, and note and record at once the starting time of the test.

3. When no more water is standing in the can, again note and record the time. For some soils, the water goes in quite slowly, so instead of waiting for all of the water to soak in, merely note the time required for the water level to drop a certain amount.

4. Run this measurement on at least three more locations that are quite different from each other, and record the data.

Data Sheet

Location and description	Amount of water	Starting time	Ending time	Total time	Time per liter or quart
Station #1					
Station #2					
Station #3					
Station #4					

Follow up:

1. To what do you think the difference of results are due?

2. Try the compactness tests (Skill #104) on the same four sites. Is there any relation between soil compactness and water infiltration rate?

3. Locate and record three areas where man has used the land and created conditions for much more water run-off than for water infiltration. What happens to the water that does run off? Whose problem does the run-off water become? How could the situation be improved?

Plot Study Unit
Skill #106 p. 1

SOIL TEMPERATURE

Objective:

1. to be able to accurately measure the surface temperature and the subsurface temperature of different soils.

Materials:

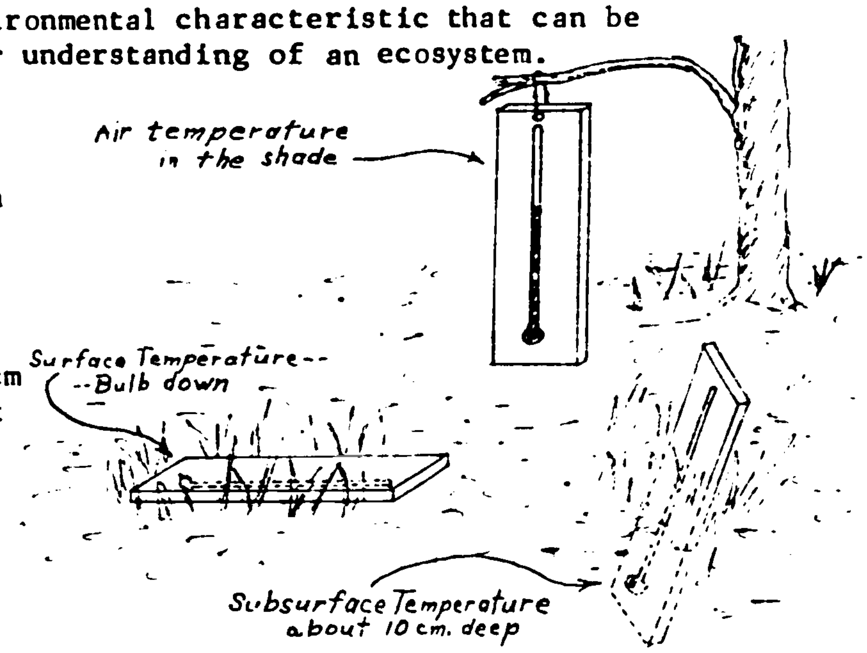
3 inexpensive thermometers which have their bulbs exposed so that the bulbs themselves can contact the soil.

Shovel.

The Idea:

On a hot day you run around in light clothing, but on a cold day you bundle up. Why? Because your own body is comfortable and works well only within a fairly narrow range of temperature. In the same way, plants roots and various animals that live in soil have narrow temperature ranges in which growth and activity can occur. The soil is a good insultating blanket. But not all soils are equally good insulators. And the kind and amount of plant growth also play a part in insulating. So the soil temperature is another environmental characteristic that can be measured and that can contribute to our understanding of an ecosystem.

What to do:



1. Lay one thermometer face down on the surface of the soil. Be sure the bulb is touching the soil.

2. Near the location of the first thermometer cut a slit about 10 to 12 cm deep, using the shovel. Force the slit open, and gently insert the second thermometer so that the bulb will be about 10 cm deep. Gently remove the shovel, and gently close the slit with dirt so that the lower part of the thermometer is sealed in the slit.

3. Leave the thermometers alone for 3 to 4 minutes, then pick up both and read them quickly. Record the results.

4. Now hang or stand one thermometer in the shade to measure air temperature. After about 5 minutes read and record this value.

5. Also record the time, the sky condition, and the Exposure (level, or a slope facing which way -- north, south, east, or west).

Data Sheet (indicate if ^oF or ^oC)

Location and description	Sky Condition	Plant Cover	Exposure	Time of Day	Air Temp	Temp. Surface TS	Temp. Sub-Surface TSS	Difference in Temps
Site A - bare pathway								
Site B - lawn								
Site C - under a bush								
Site D - a sandy area								
Others:								

Follow up:

1. What effect does exposure have on the temperature of a site? (Exposure is merely whether the slope faces towards the north, south, east, or west.)

2. Does the time of day make any difference? To check this out, make the measurements three times in one day (morning, noon, evening) and on the same location.

3. Are exposure and site temperature even considered in locating and constructing buildings?

4. How does the kind and density of plant cover affect soil temperature? How could you check this?

5. Does the kind of soil make any difference? That is, do you get the same results on a bare sandy soil and a bare clay soil, for instance?

LIGHT INTENSITY

Objective:

1. to be able to measure the intensity of light on a plot of ground.

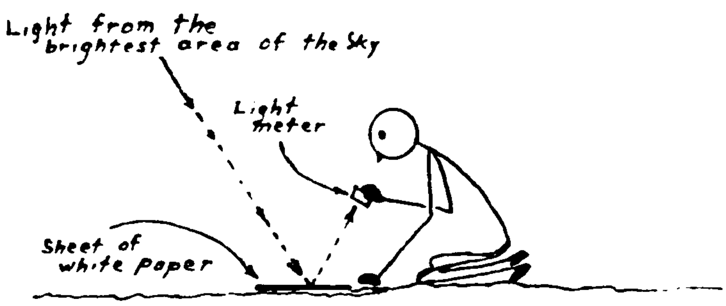
Materials:

A light meter of some kind.
A sheet of white paper.

The Idea:

In the study of ecosystems, many factors all interact to create a particular environment, and certainly the amount of light is one of them. Areas that are always shaded have a different plant cover than areas receiving direct sunlight. Plants that can grow in shade are called "tolerant" plants--that is, they are tolerant of shade. In contrast, "intolerant" plants are those that cannot grow (or grow poorly) in shade. And some species can do quite well in either. So you see that the amount and intensity of light on a particular area has a lot to do with the kinds and density of the plant cover.

What to do:



1. Locate where the sun is, and face hat direction. If you are in a shaded area, locate where the brightest piece of sky is and face that way.

2. Place the piece of white paper on the ground or on the surface vegetation in front of you.

3. Hold the light meter about 30 cm from the piece of paper.

4. Read the light meter valve and record it in whatever units that meter uses.

5. Carry out readings on many different environments and record all data. The Data Sheet suggests various environments to try.

DATA SHEET
(State units of the light meter used)

Location and Description	Date	Time	Sky Condition	Light Meter Reading	Ratio*
Site A - on an unshaded area					
Site B - under scattered trees					
Site C - under dense trees					
Site D - on the north side of a building					
Site E - on the south side of a building					
Site F - under a bush					
Others:					

*The ratio will express the relative light intensity--that is, we want the ratio of a site's light intensity value compared to the value of the brightest site. For instance, if the unshaded area gives a reading of 500 units and other values are Site B = 400, Site C = 200, Site D = 50, then with the 500 value as 1, the others become 0.8, 0.4, and 0.1. It is then easy to compare them--but they can be compared only if the three values were taken under the same sky conditions and time of year and day as the unshaded area value.

Example: Site A value = 500 units; Site C value = 200 units.

The ratio desired is $\frac{\text{Site C value}}{\text{Site A value}}$. Let L be the number value of the Ratio.

Then $\frac{L}{1} = \frac{\text{Site C value}}{\text{Site A value}}$; $\frac{L}{1} = \frac{200}{500}$; L = 0.4

Follow-up:

1. Devise some experiments for finding how light intensity affects plant growth. The write-up labeled Experiment#115 suggests one way to do this.

2. How does light intensity vary in water? Are submerged aquatic plants affected by reduced light intensity? In the write-up labeled Experiment#116 is described the construction and use of a Secchi disk that is a standard device for measuring light intensity in streams and lakes.

SOIL PROFILE
(and collection of samples for other experiments)

Objective:

1. to be able to prepare and map a soil profile.

2. to be able to prepare a sample card representing the profile.

Materials:

6 plastic sandwich bags, such as "Baggies", to collect 3 cups of soil each.
6 small squares of light plastic like Saran Wrap about 10 cm square in which to collect and display about a tablespoon of soil from each layer.
1-5"x 9" or 4"x 6" file card on which to mount the display samples.
1 shovel
1-1 cup measure.

The Idea:

We see only the surface of the ground most of the time, yet the soil environment below the surface has a great deal to do with the kind and amount of plant growth and the kind and amount of animal life present in the soil.

To discover what lies below the surface we can expose a "soil profile" --merely a vertical cross section of soil. We can then study, map, and analyse the soil layers exposed. A sample of a profile is illustrated here.

What to do:

1. In an area that is to be studied, dig a hole about 60 cm deep (about 2 ft. deep). If the area has a steeply sloping bank, the soil profile will be more easily exposed, but a hole in level ground will do although such a profile is harder to study, measure, and map.

Tag for Soil Samples

Layer #______.
Depth: from____cm to____cm.
Structure:________________
(See data sheet for other information.)

A Sample Profile

A horizon

Trash: Dry dead plant stuff.

Duff: Moist dead plants, partly decayed.

Surface Zone: Major root zone. darkest layer.

Subsurface: Lower roots Not quite as dark. Less organic matter

B horizon

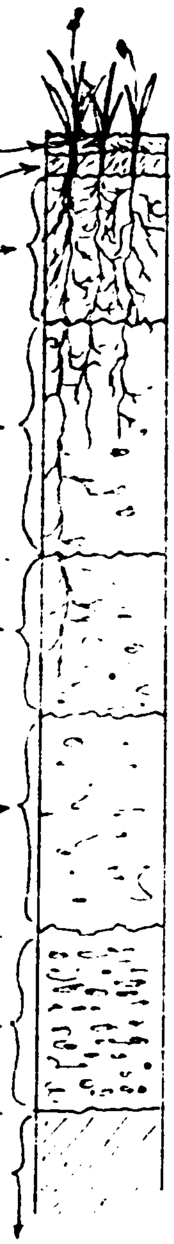
Subsoil: Few roots. Usually lighter color. May show a leached layer of light-colored material.

Lower Subsoil: No or very few roots. Little organic matter. Usually even lighter colored than subsoil.

C horizon

Parent Material: Broken up and slightly weathered bedrock material.

Bedrock



2. After the hole is dug and the profile exposed, carefully slice about one inch off of one wall, noting how the different layers break as the shovel cuts through. Note on your drawing of the profile the structure of each layer.

(Soil structure refers to how the soil particles are put together, and it is greatly affected by the amount of organic matter in each layer. The structure is called platey if the soil tends to break in horizontal cracks as the shovel is forced through the soil. It is called columnar if it breaks in generally vertical cracks. It is called massive if it breaks in an irregular way. And it is called granular if it just crumbles completely.)

3. Examine the profile carefully. Note any differences of color or content. Measure the depth of each layer.

4. Now draw a picture of the profile, to scale, on the data sheet. For each layer record its depth and thickness, note its structure, draw in the roots exposed, note any animals or animal signs found. (I once found some snake eggs at a depth of 50 cm, and another time found a living Sand Cricket at a depth of 70 cm.)

5. From each layer collect and put into a sandwich bag at least 3 cupfuls of soil. Make out a label for each sample, and attach it to the bag. These large samples will be used later for further analyses of the soil.

6. From each layer collect about 1 tablespoon full of soil. Put it in the small square of plastic and wrap it into a small flat package. Staple the package from each layer onto the file card, and label the depth of each sample. The card should also have on it your name and the location of that profile.

Follow-up:

1. There are many studies and experiments that can be made on the large samples of soil collected. Skill #109 determines soil texture and percentage composition. Skill #110 breaks the soil down by particle size in dry form. Experiment #111 determines the acid or basic character of the soil by measuring the pH, as it is called. Experiment #113 determines the amount of organic matter present. In Experiment #117 you capture the tiny living things to examine. Experiment #111 also determines the general chemical makeup of the soil.

2. Why is soil structure of any concern to people living in cities? Do house builders ever consider it? Do road builders? If you wanted a garden or flower bed near your house or even in a window box, what could you do to your soil to make it better for growing plants? Do each one of us, no matter where we live or what we do, depend on there being good soil for growing the food we must have?

DATA SHEET

SOIL PROFILE

Description of each layer

(for each layer, give the layer number, the depth and thickness (from____cm to ____cm, or ____cm thick), the structure, the color, and a record of plant parts or animals or animal signs found. After the large samples are analysed further, more data can be added to the description of each layer.)

Picture of the profile

(Scale: let each 10 cm on the profile be shown by 1 cm on this drawing.)

Layer #	Depth in cm	Picture
1.	0 cm	

SOIL ANALYSIS
(by relative density)

Objective:

1. to be able to analyse a soil by relative density.

2. to be able to calculate the percentage composition.

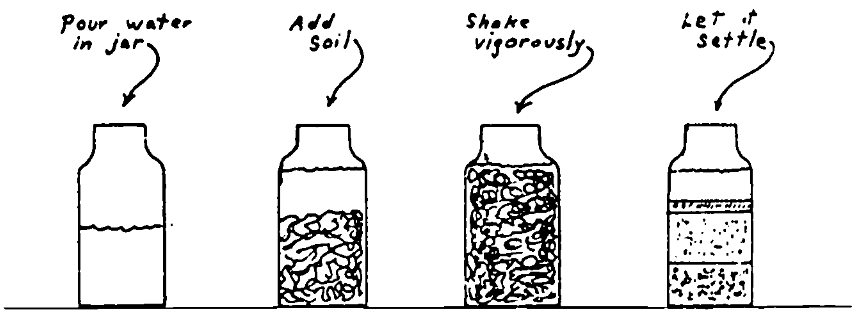
Materials:

One 1-quart jar, empty, with tight lid.
One 1-quart jar of water
Soil sample or samples (use samples collected in Soil Profile study, Skill #108) or gather new samples.
One 4"x 6" file card.

The Idea:

In the Soil Profile Study (Skill #108) one soil characteristic studied was structure--or how the soil particles were put together. This Soil Analysis study looks into soil texture--or the kinds of individual tiny soil particles, such as clay, silt, fine sand, coarse sand, pebbles, gravel.

What to do:



1. Collect about 3 cups of a soil sample. This may be from any site under study. It may be just surface soil, or you may wish to analyse each layer of the soil profile samples collected in #108. Or if you wish to get a good idea of the overall composition from a whole profile, take small amounts from each layer in proportion to the thickness of each layer.

2. Pour water into the empty jar until it is about half full.

3. Break up any chunks that are in the soil sample, then pour about 2 cups of the sample into the half-full jar of water. The water level will rise to about a three-fourths full mark. Do not fill the jar full of water. There must be some space in the jar.

4. Put on the lid tightly, then shake the jar vigorously for several minutes, so that all lumps are broken and that only basic particles are left.

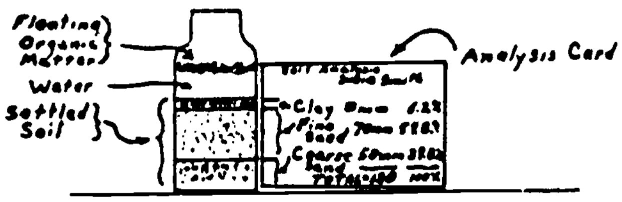
5. Put the jar aside. It may take as long as 24 hours to completely settle out.

6. When the standing water above the settled soil is clear, place the file card against the jar, and accurately mark on it the locations of the several layers that are visible.

7. Calculate the percentage composition of that sample. (See sample below.) Also record on your card your name, and the location of the sample site and the layer number or horizon. This card is your Data Sheet for that sample.

Follow-up:

1. To whom is an analysis like this important? Does such information have any use for a home builder or an engineer. List five different ways in which man uses soil and how an analysis like this could apply in deciding if each use is suitable to a particular soil.



2. Analyse separately each of the samples from the several layers exposed in a soil profile and determine how the composition of the soil changes. Can you decide from your analyses if that soil developed from the bedrock below it, or is it unrelated to the bedrock? How is it possible for a soil to not be related to or developed from the bedrock below it?

SOIL ANALYSIS
(by particle size)

Objective:

1. to be able to separate a soil into separate piles of different particle size.

Materials:

5 tin cans, such as #5 juice cans, with both ends cut out of each one.
5 squares of different wire mesh or screen. Obtain meshes of 3/4", 1/2", 1/4", 1/8", and 1/16", or any other 5 meshes.
Wire or string to tie the squares of mesh to the bottoms of the cans.
Soil samples of about one quart in volume.
One 1-quart plastic bag.
Six pieces of old newspaper.

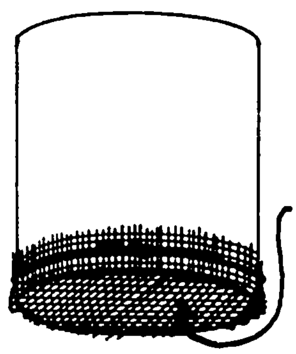
The Idea:

In #108 a Soil Profile was studied, and the structure examined. In #109 the soil texture was analysed. And in this study the particle sizes present in a soil are studied. This characteristic of soil determines how readily water and air will enter the soil.

What to do:

1. Prepare the sifting cans. Label the cans #2 through #6, with #2 the largest mesh screen. There will not be a #1 can.

2. Check your soil sample. If it has been crushed and crumbled, get another sample that is as undisturbed as possible.



3. Put the soil sample into a weighed plastic bag. Weigh the whole sample. Record the weights of the empty bag and the bag plus sample.

4. Pour some of the sample into the largest mesh can which is resting on a piece of newspaper. Lift the can a few inches off of the paper and shake it left-and-right. You can also tape it on the side, but do not shake it up and down or larger particles in the soil will be broken up. When no more soil comes through the mesh, pour onto a different piece of newspaper the particles that did not go through that mesh. Then pour in more of the sample and sift it. Continue this process until the whole sample has been sifted.

5. You now have two piles of soil. Label as #1 the pile that is soil that did not go through the largest mesh, and label as #2 the pile of soil that did go through the largest mesh.

6. Now sift all of #2 through the next sized mesh, can #3. The material that does not go through that next mesh is poured back onto the #2 paper. The soil that does go through is labeled #3.

7. In a similar way sift the soil through the other cans.

8. You now have 6 piles of soil. Weigh each pile and record the values on the Data Sheet. Calculate the percent that the weight of each pile is as compared to the weight of the original sample.

Data Sheet

(Soil Analysis by percent by weight of separate piles of sifted sample.)

Data		Calculations
Wt. of total sample + bag is	___ g.	$\frac{\#1}{S} \times 100 = \frac{\quad}{\quad} \times 100 =$ ___ % #1
Wt. of empty bag is	- ___ g.	
Wt. of sample, S, is	___ g.	$\frac{\#2}{S} \times 100 = \frac{\quad}{\quad} \times 100 =$ ___ % #2
Wt. of pile #1 is	___ g.	
Wt. of pile #2 is	___ g.	$\frac{\#3}{S} \times 100 = \frac{\quad}{\quad} \times 100 =$ ___ % #3
Wt. of pile #3 is	___ g.	$\frac{\#4}{S} \times 100 = \frac{\quad}{\quad} \times 100 =$ ___ % #4
Wt. of pile #4 is	___ g.	
Wt. of pile #5 is	___ g.	$\frac{\#5}{S} \times 100 = \frac{\quad}{\quad} \times 100 =$ ___ % #5
Wt. of pile #6 is	___ g.	$\frac{\#6}{S} \times 100 = \frac{\quad}{\quad} \times 100 =$ ___ % #6

Follow-up:

1. How could you relate particle size information to the ability of a soil to take in water and air?

2. Some soils tend to become quickly sealed when rained on. Why do you think this occurs? What are some limitations of the use of such soils?

3. Some soils take in water very readily and in large amounts. What kinds of soil would act this way? Under what kinds of uses is that an advantage? When would it be a disadvantage?

4. Do soils which readily take in water also lose it quickly by evaporation? Do soils which take in water slowly also lose it slowly by evaporation? How could you find out?

SOIL CHEMICALS

Objective:

1. to be able to measure the pH, or acidity, of soil.
2. to be able to determine some of the chemicals that are in the soil.

Materials:

For the acidity test, either a roll of Hydrion Paper or a simple pH test kit.
For the soil chemicals test, a simple Soil Test kit.

The Idea:

1. Acidity or pH

Soils show acidic, neutral, or basic qualities, depending on the kind of rock from which they developed and on where they are located in relation to rainfall. Soils in areas of more than 20 inches of rainfall per year are acidic. Soils in areas of less than 20 inches of rainfall are basic. Soils close to or in areas of 20 inches of rainfall are neutral.

The acidic or basic quality of soil is measured on a scale from 0 to 14 and this is called the pH scale. On this scale, 7 is neutral, more than 7 is basic, and less than 7 is acidic. The scale is built on negative powers of 10, that is: $1/10 = 10^{-1}$, $1/100 = 10^{-2}$, $1/1000 = 10^{-3}$, $1/10,000,000 = 10^{-7}$, and so on up to 10^{-14}. The pH scale uses just the exponents or the small numbers 1, 2, 3, etc., up to 14. And when one finds a soil solution of pH = 5 it means that the concentration of hydrogen ion (the charged chemical particle that causes acidity) is only 1/100,000, or 10^{-5}, or .00001. Another soil of pH = 6 would have a concentration of hydrogen ion of only .000001, or 1/10 as much as the pH = 5 soil. Another way to say this is that the pH 5 soil is ten times as acidic as the pH 6 soil. So a difference of 1 on the pH scale is quite a large difference, and plants are adapted to grow in soils of a particular pH range for each species.

2. Soil Chemicals

All plants need certain chemical elements in certain quantities to grow properly. Four of the most critical elements are calcium (symbol Ca), Potassium (symbol K), Phosphorus (symbol P), and Nitrogen (symbol N). Many other elements are also necessary to plants but often in very small amounts.

Even though a soil may have good structure, good texture, a suitable pH, and adequate water, it may not be able to grow healthy, nutritious, vigorous plants if the soil has a lack of certain chemicals. So a knowledge of the chemicals present or lacking in a soil being studied is important in understanding the potentials or limitations of the soil.

<u>What to do</u>:

Since there are available a number of different materials and kits for measuring pH and for measuring certain chemicals, specific instructions are not given here. Instead, you should carefully follow the instructions of the particular kit you have available.

<u>Follow-up</u>:

1. How do the pH and the chemical content vary among the several samples taken from the different layers and horizons of a soil profile. (If you have carried out Skill #108 you have the samples from a profile.)

2. How does the vegetation vary on soils of different pH?

3. If a soil is lacking certain needed chemicals, how can the lack be corrected?

4. If a soil is highly basic (of, say, pH 9 or 10) how could it be made less basic? What could you apply to the land? What can be done to a soil that is highly acidic (of, say, pH 4 or 5)?

5. Of what importance is it to a home builder to know the chemical nature of his soil? Does it matter to the highway engineer, the real estate developer, or to the farmer?

6. What are some of the problems faced in trying to restore the plant life on strip-mined land?

WATER CONTENT OF SOIL

Objective:

1. to be able to find the weight of water in a soil sample.
2. to be able to express the water content as a weight percent of the total sample.

Materials:

One soil sample, freshly dug, and not allowed to start drying out until you are ready to do this experiment. Take the sample for this experiment from the A horizon (see #108).
One empty tin can. A 1-pound coffee can works well.
Some old newspapers.
A balance or scales that can weigh objects up to 1000 grams and is accurate to 0.1 grams.

The Idea:

Soil moisture obviously is necessary for plant growth. But not all soils take in water at the same rate (see #105), nor hold onto the same quantity of water. In this experiment you will find out how to accurately measure the amount of water in soil, in terms of the amount that can be driven off just by drying the soil in the air, then also (if you wish) the additional amount that can be driven off by warming the soil in an oven.

What to do:

1. Weigh the empty coffee can. Record this value.
2. Fill the can about 3/4 full of soil and weigh it again. Record
3. Place the newspaper on a table or counter indoors and where it won't be in the way.
4. Pour out the soil sample onto the newspaper. Don't spill any. Spread the soil thinly, so that it will air-dry rapidly.
5. Allow the soil to air-dry for 2 days. Stir it occasionally, but be careful not to spill or lose any of the soil.
6. Transfer the soil back into the coffee can.
7. Weigh the can plus soil. Record this weight.
8. Again pour the soil out on the paper, spread it, and let it dry for one more day.
9. Again transfer the soil back to the can, and weigh the can plus soil. Record this weight. Compare this weight to the weight of can plus soil after only 2 days of drying. If they are the same, then the air drying job is done. If the 3-day drying value is less than the 2-day drying value, more water has been lost and you cannot be sure it is completely air dried. If that is the case, repeat steps 8 and 9 until there is no further loss of weight. You can then be sure the sample is completely air dried.
10. Calculate the loss in weight of can plus soil at the start compared to can plus soil when completely air dried.
11. Calculate the percent that the weight loss is, compared to the original weight of soil (without the can).

12. A further series of drying and weighing steps can be taken with the drying done in a regular kitchen oven set at about 300° F. Let it stay in the oven at least 2 hours. If you do this, you may find a small amount of additional water is lost. The higher the air humidity (moisture in the air) when you were air drying, the less efficient the air drying will be in removing all of the water.

13. Save the sample, for now that it is dried it can be used for Skill #113.

Follow-up:

1. Compare the water content of a sandy soil, a good loamy soil, and a clay soil. Be sure the three samples all have had only rain on them, and have not been irrigated.

2. What are some of the advantages and disadvantages to soil having a high water content? Does the purpose for which the soil is to be used make any difference?

ORGANIC MATTER CONTENT OF SOIL

Objective:

1. to be able to find the weight of organic matter in a soil sample.
2. to be able to express the organic matter content as a weight percent of the total sample.

Materials:

One soil sample that has been air dried. Use the same can and sample that you air dried in Skill #112.
A gas burner or a Fisher-type laboratory burner, or a gasoline or propane pressure stove---something that will get the can and sample very hot. CAUTION: Do the heating only with adult help.
A balance or scales that can weigh objects up to 1000 grams, and is accurate to 0.1 grams.

The Idea:

The organic matter in soil is extremely important in creating a good soil environment for plants and animals. It is important for creating good soil structure, for holding water in the soil, and for returning chemicals to the soil. In this experiment you will actually find the amount of organic matter in a soil.

What to do:

1. If you have the air-dried sample from #112 you are ready to go. If you do not have such a sample, then collect a fresh sample and carry out the steps in #112 to find the weight percent of water.

2. Now put the can plus soil on the burner or stove. Turn on the stove. Be sure there is good ventilation,for heating the sample actually burns out the organic matter. Heat the sample on full blast for about one hour. Stir the sample occasionally with a metal (not wood) rod, such as a piece of coat hanger.

3. Turn off the burner, Let the can and soil cool until you can touch it comfortably with your bare hands.

4. Weigh the can plus sample. Record this weight (the data sheet for this is combined with the data sheet for #112).

5. Again heat the can plus sample for another hour. Let it cool. Weigh it. Record the weight. If the weight is the same as after the first heating, then the organic matter is all burned out. If there has been a further weight loss since the first heating, then obviously not all the organic matter was burned out with the first heating. In that case a third heating (for 1 hour), cooling, weighing, and recording is needed. This process must be repeated until no further weight loss occurs.

6. Now calculate the weight percent of organic matter in the original sample.

Follow-up:

1. Compare the organic matter content of two quite different soil samples. You might try a forest soil, a grassland range soil, a lawn soil, a subsoil sample, an alfalfa field soil, a corn field soil, or a flower garden soil. One interesting comparison would be a sample of the thin topsoil of a strip-mining area and a sample of the soil (largely subsoil) on which vegetation must be grown to restore the area after mining.

2. Is there any tie between organic matter content and other soil qualities or characteristics you have studied and measured?

DATA SHEETS FOR SKILLS #112 AND #113

Water Content of Soil
Data Sheet

1. Weight of empty can ____ g.
2. Weight of can plus fresh soil sample ____ g.
3. Weight of can + soil after 2 days drying ____ g.
4. Weight of can + soil after 3 days drying ____ g.
5. Weight of can + soil after 4 days drying ____ g.
6. Weight of can + soil after 5 days drying ____ g.

(Repeat drying and weighing only until no more weight loss occurs.)

Calculations

Wt. from step #2 ____ g.
minus wt. from step #1 ____ g.

Wt. of fresh soil sample ____ g. *

Wt. from step #2 ____ g.
minus wt. from last drying step done ____ g.

Wt. of water lost ____ g.

$\frac{\text{Wt. of water lost}}{\text{*Wt. of fresh soil sample}} \times 100 =$

percent of water in original sample

____ X 100 = % water

Organic Matter Content of Soil
Data Sheet

1. Weight of empty can ____ g.
2. Weight of can + fresh soil sample ____ g.
3. Weight of can + air dried sample ____ g.
4. Weight of can + soil after 1 heating ____ g.
5. Weight of can + soil after 2 heatings ____ g.
6. Weight of can + soil after 3 heatings ____ g.

(Repeat heating and weighing until no more weight loss occurs.)

Calculations

Wt. of fresh soil sample ____ g.
(see * in other column)

Wt. from step #2 above ____ g.
minus wt. from last heating step (no more loss) ____ g.

Wt. of organic matter burned out of sample ____ g.

$\frac{\text{Wt. of organic matter}}{\text{*Wt. of fresh soil sample}} \times 100 =$

percent of organic matter in original sample

____ X 100 = % Organic matter

COMPLETE MAPPING OF A PLOT
(based on Skills #101 through #113)

Objective:

1. to apply the skills learned in #101 through #113 to a small plot of ground.
2. to develop a complete map of the plot.

Materials:

The materials for each separate skill, plus about 7 meters of extra string and 2 dozen extra flower pot stakes.

The Idea:

The separate skills can now be applied to a complete study of a small plot of ground. Page 4 of this #114 shows a completed map with all data recorded on it including the soil analysis and the soil profile. Page 5 is a blank sheet on which you can build your own map and page 6 is for your soil profile and soil analysis work.

What to do:

1. Locate an interesting plot of ground--one that has an irregular sloping surface and a variety of plant cover.

2. On the ground stake out the 4 corners of a plot 1 meter x 1 meter, and run a string around it to mark it clearly. Note on your map the scale to which it is drawn.

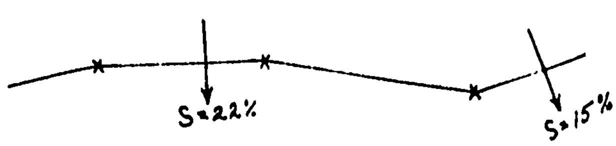
3. Show on the map the type and density of plant cover, in enough detail to give a correct general idea to the reader of your map. (See sample map for an example. A color or number key is often helpful in identifying the plant cover.)

4. Also map the location of the animals you find, or the signs of animals, including signs of man. You really need to get your eyes down close to the ground and examine it minutely to do this properly.

5. Find the maximum change of elevation on your plot, and calculate the contour interval you wish to use. (See #102) Mark it on your map, and locate and mark one point for each of the contour lines you will develop.

6. Stake out the contour lines (see #101). Mark them in their proper places on the map, this way:

7. Make at least two slope measurements along each contour line (see #103). Calculate the percent of slope and record each in its correct place on its contour line, like this: (the arrow should point in the downhill direction.)



8. Measure the soil compactness in several places having apparent differences of cover (see #104). Mark these on the map as: C = ___ cm.

9. Measure the water infiltration rate in at least two places having different cover. (See #105) Mark it on the map as: W= ___ min ___ sec/quart

10. Measure the light intensity on 2 spots of the plot (see #107). On the map note these as: L= ___ units on meter

11. Measure and record soil temperatures in several locations (see #106 On the map write TS= ___°F for temperature of surface, and TSS= ___°F for temperature of subsurface. Also record the air temperature on the bottom of the map.

12. Cut a soil profile (see #108) and draw a picture of it on the side of your map. Do <u>not</u> cut this profile where a water infiltration test was done, or the soil color will be affected by the water.

13. Dig out representative soil samples from the exposed profile. Take about two liters (roughly two quarts), or else the 3 cup samples from each layer of the profile. Crumble the soil as little as possible. Take this sample indoors, and do the following:

(a) Make a soil composition analysis (see #109). Record the results on the side of the map, showing percentage of each visible layer.

(b) Make a particle size analysis (see #110).

(c) Make an analysis of the water content of the soil (see #112). Record on the map the percent of free water.

(d) Make an analysis of the organic content of the soil (see #113), and record on the map the percent of organic matter in the soil.

(e) Make a measurement of the pH of the soil or, if the differences visible in the soil profile are quite clear, make a pH measurement of each distinct horizon of the soil (see #111). Record these data on the picture of the soil profile. If a complete soil test kit is available, measure other chemical characteristics of the soil of different horizons.

14. The map is now quite complete. You may figure out other investigations to make. But what you have is a quite complete picture of a small area.

You now have the skills to make any of these many separate investigations on any area, and to relate them to overall plant cover, or to possible wildlife habitat, or to the ways in which people have used or abused a particular site.

<u>Follow-up</u>: (Here are some questions to think about and to investigate. You probably can think of others, too.)

1. What kind of soil is suitable for a sewage septic field?

2. Why does the highway department often have difficulty (if it even tries) in establishing plant cover on road cuts or road banks? What could it do to improve the chances of success?

3. Are all soils equally good as insulation? How could you find out?

4. Do animals dig burrows in all kinds of soil, or in just some kinds? Why?

5. What would be a suitable soil environment on which to establish a small park? Does the City Park Department ever consider this in selecting a site for a future park?

6. Do all soils erode at the same rate if they have the same slope? How could you find out?

7. Does a house contractor always look carefully into the soil characteristics before building a house? Can you locate some houses in your neighborhood that have soil problems of some kind? What are the problems? How could the problems have been avoided, or should the house not have been built there?

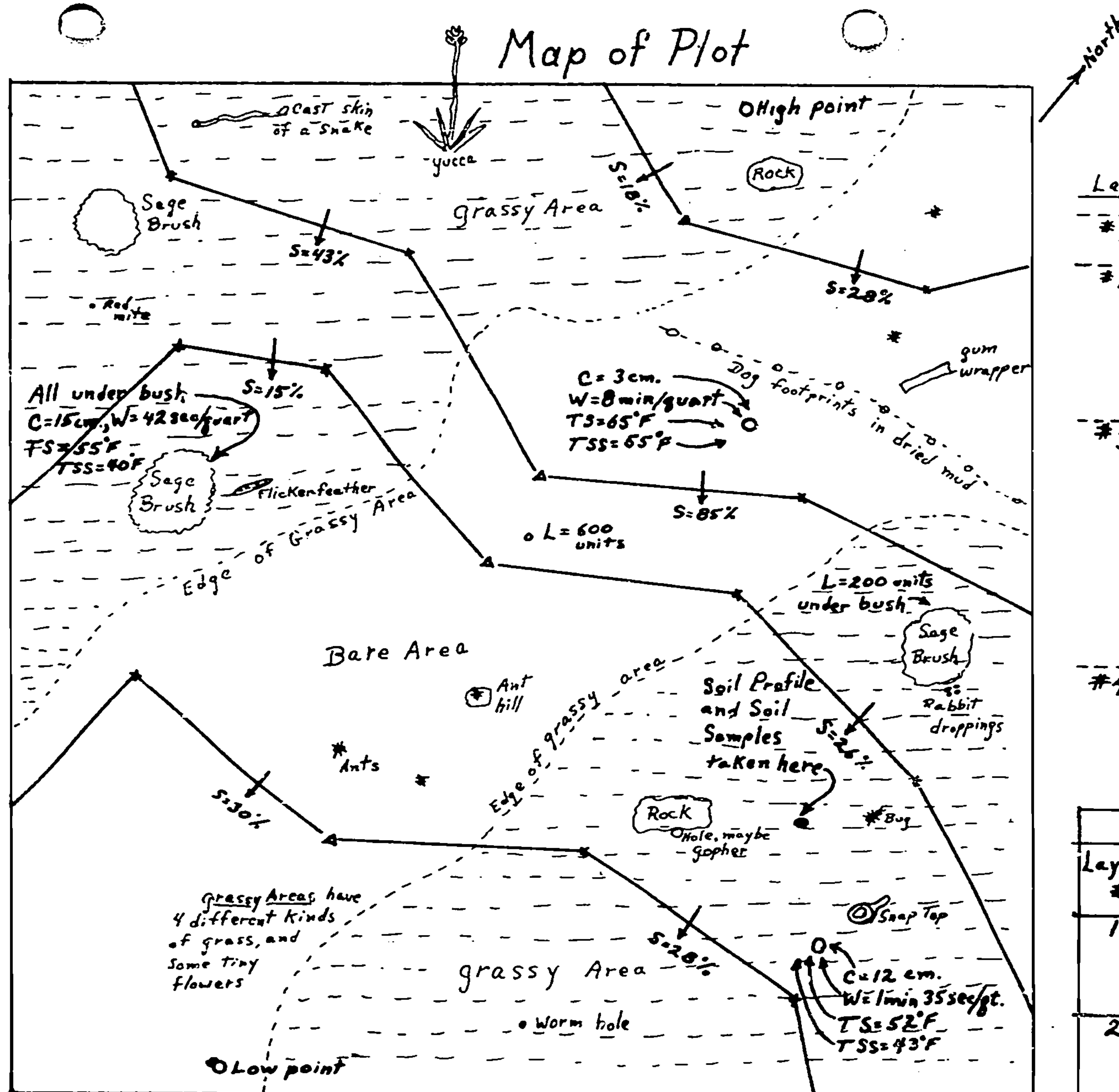
8. What are the characteristics of a soil good for growing vegetables or flowers in small home gardens or on farms? Do different kinds of crops have different soil needs?

9. Why do so many people collect the grass clippings and throw them in the garbage when they mow their lawns? Is this a good or a poor practice -- or does it depend on the circumstances? How much organic matter is removed per square meter when a lawn is mowed and the clippings collected? How does "peat moss" compare to grass clippings as a source of soil organic matter?

10. What are the soil conditions around your school? What problems are there in owing things there, such as grass or shrubs or trees? What has been done to overcome those problems? Can you suggest other solutions?

SAMPLE MAP AND DATA SHEET FOR PLOT STUDY

Map of Plot



Change of Elevation=35 cm. 4 contour lines wanted. so Contour Interval=7cm

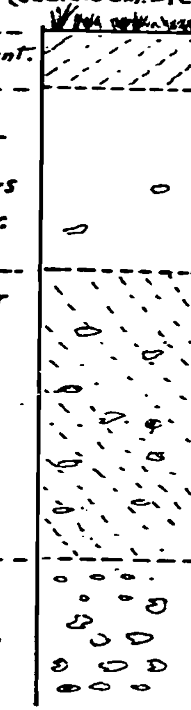
Scale: 1 meter = 14 cm. ▲ = starting point for each contour line.

Symbols: S= % of Slope; C= Compactness in cm.; W= Water Infiltration; TS= Surface Temp.; TSS= Subsurface Temp. at about 10cm. deep; Contour Lines. Air Temp.=60°F. Sky clear. Time Temps. taken was 10:00 a.m. L= Light meter reading

Soil Profile

Layer	Depth	Description
	0 cm.	
#1		Dark brown. High organic content. Dense roots.
	4cm.	
#2		Slightly lighter color. A few pebbles. Roots plentiful. Not a sharp contrast with layers above and below this layer.
	15cm	
#3		Lighter color than #2. Fewer roots. More pebbles and stones
	34cm	
#4		Sharp color difference. Very few roots. Many stones. Stones appear to be sandy shales.

(Scale: 5cm.=1cm)



Detailed Data from Soil Profile Samples

Layer #	Structure	Texture	Particle Size	pH	% Water by Weight	% Organic Matter
1.	Columnar	Sand 70% Clay 30%	1/16 = 30% 1/8 = 55% 1/4 = 10% 1/2 = 5%	7.8	40%	60%
2.	Columnar to Massive	Sand 60% Clay 25% Stones 15%	1/16 = 40% 1/8 = 25% 1/4 = 15% >1/2 = 20%	8.0	35%	38%
3.	Massive to granular	Sand 65% Clay 20% Stones 25%	1/16 = 30% 1/8 = 20% 1/4 = 20% >1/2 = 30%	8.1	22%	15%
4.	Granular -gravelly	Sand 40% Clay 15% Stones 45%	1/16 = 30% 1/8 = 12% 1/4 = 10% >1/2 = 48%	8.1	12%	6%

Skill #114 p. 5
Data Sheet

MAP OF PLOT STUDY AREA

Student's Names:________________________
______________________,______________________

Location of Plot:

Change of elevation = ____cm. ____contour lines wanted. So Contour Interval = ____cm.
Scale: 1 meter = 20 cm.
Symbols: S = % of slope; C = Compactness in cm.; W = water infiltration time for 1 qt. of water; TS = Surface Temperature; TSS = Subsurface Temperature at about 10 cm. deep; = Starting point for each contour line; L = light meter reading; contour lines.
Data: Air Temp. = ____° _. Sky condition: ; Time of day temps. taken______.
Put North Arrow on the map edge to show direction.

DATA SHEET FOR SOIL STUDIES

DETAILED DATA FROM SOIL PROFILE SAMPLES

Layer #	Structure	Texture	Particle Size	pH	Chemical Analysis	%Water	%Organic Matter

SOIL PROFILE--Scale of picture: ______

Layer#	Depth	Description
1.	0 cm	

Students Names: ______

Geography Study

Introduction to this Unit

Wherever we are on this earth it is necessary to learn about the area by using some simple tools of geography. A map represents a portion of the earth. In these units (the #200's) you will find out how to measure a portion of the earth's surface. You will learn how to make a simple map of an area. You will learn how to convert land measurements in common use to the metric system. You should be able to understand the size of an acre of land and to use this particular measurement of land in relation to such things as food production and the average amount of land available per person for food production in our country and in other countries you read about. You will learn how to compare the metric land measure, a hectare, with our English acre. Directions are used by everyone in daily living. You will learn about wind directions and how to tell from what direction winds are blowing. A compass rose is the device you will make to help you with directions wherever you are. Mapping is fun! You will enjoy making maps in this unit.

Weather is always with us and it affects our lives everywhere. In some of these units you will make weather observations, record the observations, compare your observations with the official weather reports from the United States Weather Service at your local airport. In this unit you will be able to combine several skills in setting up a weather station, observing the weather, and making a record of it. You will learn how to use all of the ideas in this unit, and to tie them in with other units you have studied or will be studying. And the overall objective of all of these studies is to help you learn about our total environment (the world around us), so that endeavors to solve environmental problems are based on sound understanding of the basic ingredients of the environment.

Instructions

For each unit, read the instructions carefully before starting your work. Fill in on the data sheets the information you have collected so you can refer to it at a later time. Be very exacting in all your measurements and in the recording of measurements. It is very helpful to work with a partner so you can check and correct errors in your work.

MEASURING YOUR STEP

Objective:

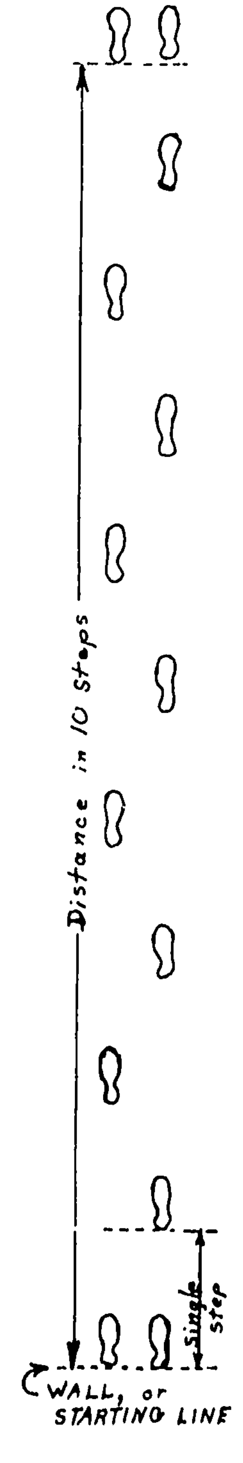
To learn how long your step is, so that you may use it for measuring distances in mapping.

Materials:

A yardstick, meter stick, or tape measure of some kind.

The Idea:

Frequently we need to know the size of a room or of a plot of ground, or the distance between places. Men in the Armed Service need to know how to locate a place without actually measuring the distance. Many of our own body measurements give us little rulers with which to measure things. In grownups the average length of the middle bone in the forefinger is an inch; the average distance from the end of an arm outstretched sideways to the tip of the nose is a yard. And a person's step or stride, once he knows how long it is, gives a handy way of measuring distance.



What to do:

A. Single step

1. Place both heels touching . line or a wall.
2. Take a normal step forward, and mark where your heel hits.
3. Measure the distance from heel to heel.
4. Do this six different times, and record the measurement of each.
5. Average the figure, to get the size of your average step.

B. Walking a line

1. Stand with your heels on a starting line. or against a wall.
2. Take ten normal, comfortable steps forward.
3. Mark the spot where your heel hits on the last step.
4. Measure the full distance of the ten steps. Record it.
5. Do this two more times, and record each measurement.
6. Find the average of the three 10-step measurements.
7. Divide this average by 10, to find the size of your step.
8. Be sure to state the unit of measurement of your step length. (Is it in inches, feet, meters, or what?)

DATA SHEET

A. Single Step Measurements

B. 10-step Measurements

Partner #1. Name ____________________

Units Used: ______________

Single Steps

1	2	3	4	5	6	Average

Average length of step in ft. and inches is: ________

Average length of step in meters is: ________

Full distance covered in 10 steps

1st Run	2nd Run	3rd Run	Average

Average length of step in ft. and inches is: ________

Average length of step in meters is: ________

Partner #2. Name ____________________

Units Used: ______________

Single Steps

1	2	3	4	5	6	Average

Average length of step in ft. and inches: ________

Average length of step in meters is: ________

Full distance covered in 10 steps

1st Run	2nd Run	3rd Run	Average

Average length of step in ft. and inches is: ________

Average length of step in meters is: ________

SURVEYING A PLOT OF GROUND

Objectives:

1. -- to be able to set a straight line of stakes.
2. -- to establish the boundaries of a square or rectangular plot of ground.
3. -- to measure the length of each side of the plot, and find the perimeter of the plot.

Materials:

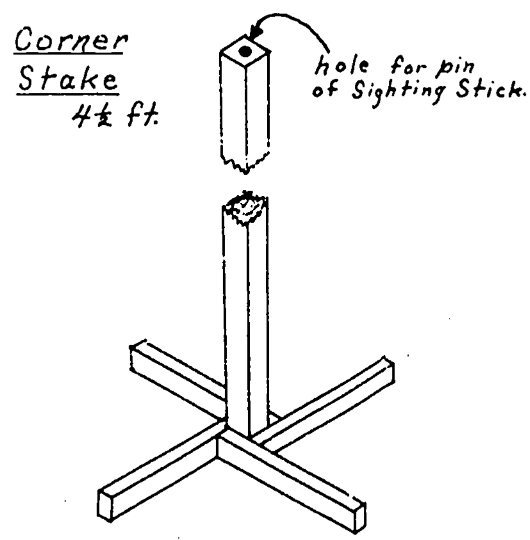
1. 4 wooden corner stakes, about 2 inches by 2 inches by 5 feet, each sharpened at one end. The top of each corner stake must have a hole drilled in it to take the pin (nail) of the sighting stick. If the ground is hard, or if you are measuring on an asphalt playground, use corner stakes only 4½ feet tall with a base of cross-pieces to hold it up, as shown in the diagram below.

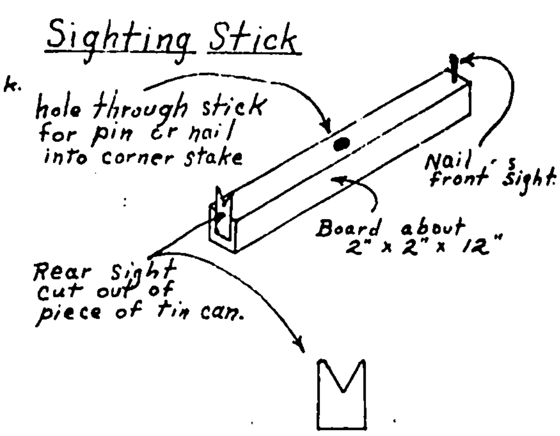
2. 1 bundle of survey stakes (24 stakes, each 16 inches long and about 1 inch by 2 inches, each sharpened at one end).

3. One 50-foot tape measure -- reel type of cloth tape is very adequate.

4. A sighting stick (see diagram), fixed so that it can be attached to the top of a corner stake.

5. Data sheet at the end of this unit, for recording information and drawing a map.





Definition:

1. A "plot of ground" is simply any size or shape of ground which you select for your project.

2. The perimeter of the plot is the total distance around the plot -- the sum of the measurements of the sides of the plot.

The Idea:

In order to manage land we always need to identify the plot of ground we're talking about. We must locate, stake, measure, and finally map the particular plot of ground. And to do that we must be able to sight, stake, and measure a straight line for each side. That's what you are doing in this unit.

What to do: (work in at least pairs, or in teams of 3 or 4)

1. Select a location on your school grounds (or nearby) where you can stake out a plot. A square or a rectangular plot is best to use for this project rather than an irregular shaped plot.

2. Drive a stake at one corner, and call this point A. If the ground is hard, use a corner stake with a base.

3. Put a corner stake at the next corner, call it point B.

4. Put a sighting stick on top of corner stake A.

5. Sight from A to B. Have your partner then walk slowly from A to B. About every 10 steps have him put in a survey stake. Keep him going in a straight line by sighting continually from A to B, and telling him when he is drifting off the line. You have now staked out a straight line, and it is one full side of your plot.

6. Now move the sighting stick to the B corner stake. Put a corner stake at the next corner, call it point C. Side BC should be at a right angle from side AB, if you have chosen a square or rectangular plot.

7. Sight and stake out side B to C.

8. Move to C, and in the same manner sight and stake C to D.

9. Move to D, and sight and stake D to A, the starting point.

10. Now you and your partner each carefully count the number of steps you each take from A to B, then B to C, then C to D, then D to A. Record these data.

11. From Skill #201 you found out the length of your step. Use this, times the number of steps, to find the length of each side of the plot. Find the perimeter.

12. Now use the reel tape measure and carefully measure each side. Find the perimeter.

13. Compare the two perimeter values. How close does your step-measurement come to the accurate tape measurement?

DATA SHEET

1. Measurements in steps -- from #201 record length of step (state nits)

Step of partner #1 is ________ long.

Step of partner #2 is ________ long.

	A to B	B to C	C to D	D to A	Perimeter
Partner #1 Number of steps					
Times distance per step equals length of side					
Partner #2 Number of steps					
Times distance per step equals length of side					

2. Measurements with the tape

(state units)	A to B	B to C	C to D	D to A	Perimeter
Number of feet or meters					

3. Map of the plot. Decide on a scale of a certain number of feet on the plot to be shown by one inch on this map, then draw the map. (If you are not sure of what a scale is or how to use it, refer to Skill #205.)

STAKING AND MEASURING A ONE-ACRE PLOT OF GROUND AND A ONE-HECTARE PLOT OF GROUND

Objectives:

1. -- to be able to accurately lay out a plot of ground one acre in area.

2. -- to be able to lay out a plot of ground one hectare in area (see definitions for what a hectare is).

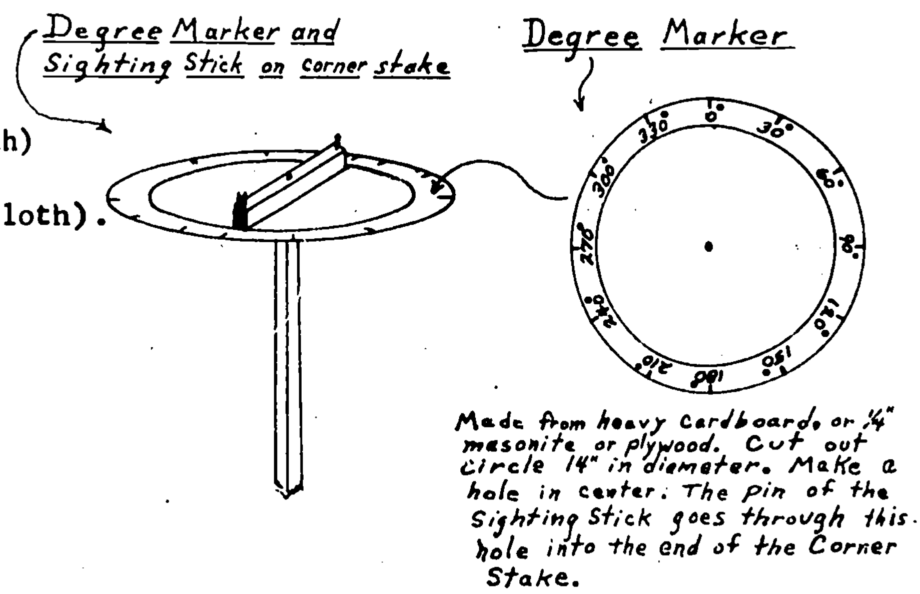
Materials:

1. Corner stakes (see Skill #202).

2. Sighting stick (see Skill #202).

3. One reel tape measure (cloth) of 50 ft. or of 100 ft. length, and one of 50 meters or 10 meters (cloth).

4. One Degree Marker, for "turning" square corners, built as shown in the diagram.



Definitions:

1. Area -- the surface measurement, in square units, such as in square feet, or in square meters. The Acre is also an area measurement, and in the metric system the Hectare (pronounced hĕk'târ) is an area measurement.

2. One acre contains 43,560 square feet. The shape of the plot -- square, rectangular, with curved sides, triangular -- doesn't matter. If it contains 43,560 square feet, it is one acre in area.

3. An acre on a square plot is 208.8 feet on each side. We will use 209 feet.

4. One Hectare contains 10,000 square meters -- so a hectare on a square plot would be 100 meters on each side.

5. One Hectare is equal to 2.471 acres.

6. One acre is 0.405 hectares.

The Idea:

One of the units of measure of land is an acre. In many countries the measure is a hectare. The size of a farm is commonly given in acres. A section of land contains 640 acres, and 640 acres equals one square mile. (Sometimes the surveys

were not exact.) Production of wheat and other grains generally are stated as bushels of grain per acre. The dollar value of land is usually given as a price per acre. A very important idea is the amount of land suitable for growing food crops. In the United States there are about 2½ acres per person that can grow food and fiber. As our population increases less land per person remains. Also when good crop land is taken for highways, cities and uses other than the growing of crops, the amount of cropland decreases. You probably know of other ways in which the measure of an acre is used.

What to do: (work in teams of 3 or 4)

1. Locate a place on your school grounds or on a nearby open area where there is enough room to lay out a plot about 425 ft. long by about 210 ft. wide. Roughly step off these distances to be sure you have enough room for doing this unit.

2. Put a corner stake at the starting point, A.

3. Put the sighting stick (see #202) on the corner stake. One partner sights in the direction of one side of the plot. Two other partners carefully step off 209 feet in a straight line, being kept "on course" by the sighting partner. The fourth partner then places the next corner stake. The two measuring partners then check the distance using the tape, and the fourth partner corrects the location of the corner stake. This is point B.

4. On the B corner stake place the Degree Marker and the Sighting Stick. Set the Sighting Stick on zero of the degree marker. Hold the Degree Marker and Sighting Stick together, and sight back from B towards A.

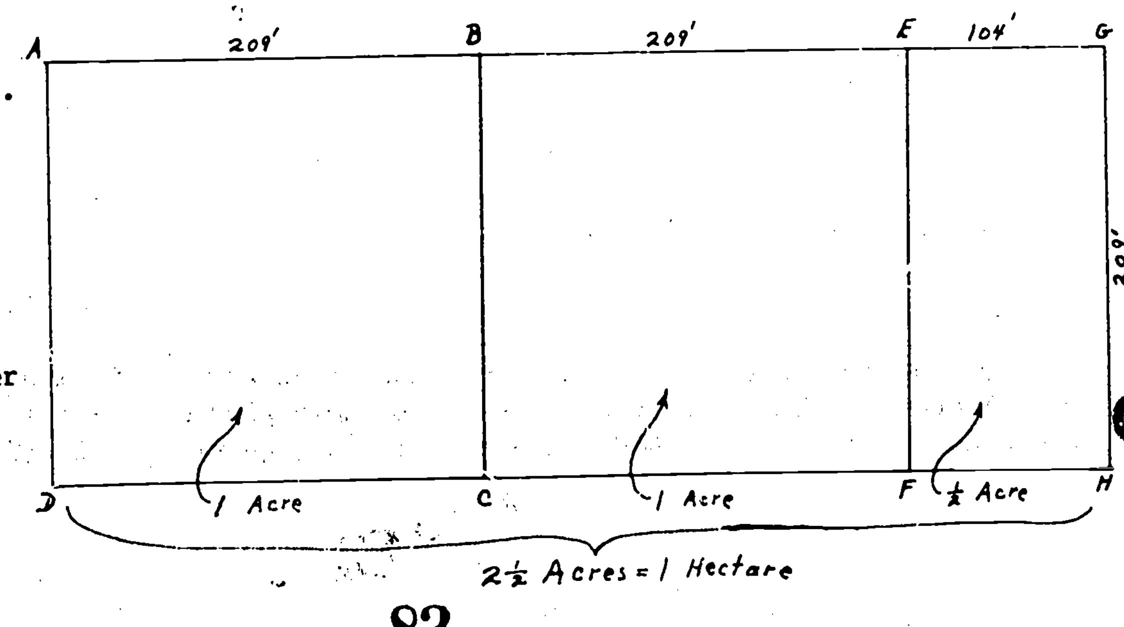
5. One partner now holds the Degree Marker so that it won't move. The sighting partner then swings the Sighting Stick 90° from zero. (If the next side, B to C, is to the right of the sighter, the sighting stick is swung to 90° mark. If the next side BC is to the sighter's left, the sighting stick is set to the 270° mark.)

6. The Sighter then directs two other partners as they again measure off 209 feet and place the corner stake, C.

7. The Degree Marker and Sighting Stick are moved to C. As at B, set the Sighting Stick on 0° and sight back to B. Hold the Degree Marker so it won't move, and swing the sighter to 90° or to 270°, to establish line CD. Again measure 209 feet and set a corner stake, D.

8. Move to D and repeat the process. If angles and measurements have been made carefully, the last line should end on the first stake, A.

9. As a further check, move the sighter to A, and see if line AB is at 90° to line AD.



10. You have now laid out a one-acre plot.

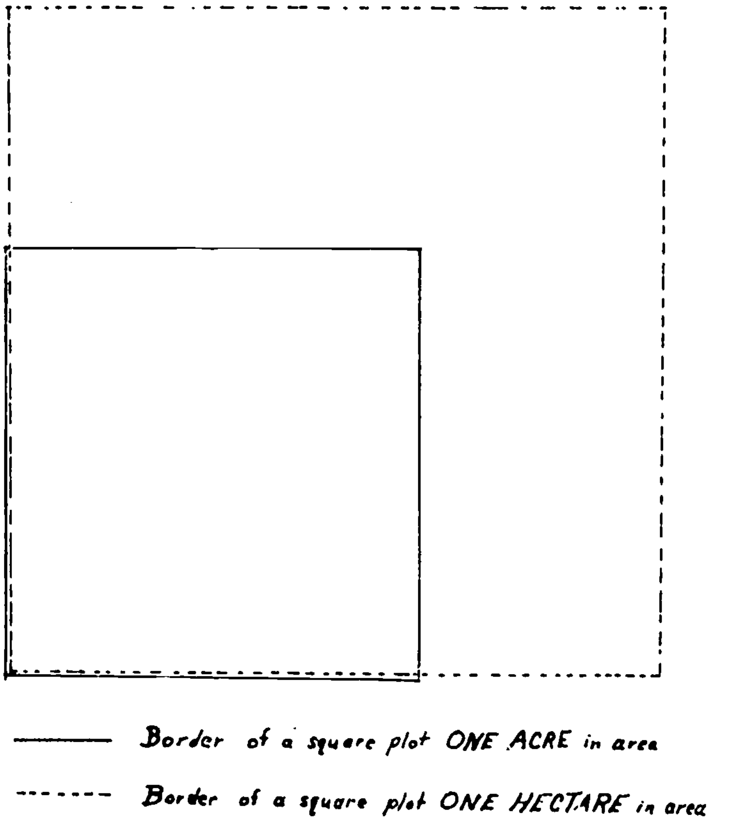
11. To be able to compare a one-acre plot to a one-hectare plot, you can now start at B, and continue the line AB for another 209 feet (call this point E), and continue along another 104 feet (call this point G).

12. At G, turn 90° and lay out a line 209 feet long (call this point H).

13. Then from H turn 90° and aim back towards line CD. Measure 104 feet (mark this F). Continue the line another 209 feet and you should reach corner C.

14. The plot ABCD is one acre. The plot BEFD is another acre. The plot EGHF is one-half acre. The whole plot AGHD is 2½ acres -- and is very close to one hectare.

15. If you have a meter tape, now measure the whole plot AGHD, record the length and the width, multiply the two values, and see how close you come to 10,000 square meters.



Follow up:

To gain another view of one acre as compared to one hectare, lay out an acre as done in this unit, then use a 50 meter or 100 meter tape and lay out a square 100 meters on each side.

USING A COMPASS AND MAKING A "COMPASS ROSE"

Objectives:

1. -- to be able to tell directions by use of a compass.

2. -- to be able to mark on the ground the magnetic north and the true north by using a compass.

3. -- to mark a complete "compass rose".

4. -- to be able to check the true north line against the north star.

Materials:

An inexpensive compass.

Two sticks like yard sticks or meter sticks.

A few pieces of chalk.

10 nails, such as 1 inch roofing-paper nails with large heads.

A hammer.

A piece of newspaper that is cut to exactly a square, as large as possible.

A small piece of cloth (red if possible) to tear into small 1 inch squares to mark the nails that are driven into the ground.

A Sighting Stick (see #202).
(Note: to use the sighting stick you will need to drill a hole sideways through the top end of one corner stake (see #202) for the pin of the sighting stick to go in.)

Definitions:

A compass is a magnetized needle, free to swing in a flat (horizontal) direction.

Magnetic North is the point on the earth's surface to which the compass needle points. This point is called the magnetic north pole.

True North is the exact geographic north pole.

The Idea:

Directions are often confusing in our daily life. Buildings are not always built in such a way that walls are north-south and east-west in direction. Roads twist and turn. Rivers run in almost any direction. Winds blow from all directions. Airplanes and ships travel in all directions.

A map should show true north in order for you to understand how maps represent a portion of the earth. We need to know true directions, and magnetic directions, and how to show them on maps and in other places too.

(Part A)

What to do:

1. Lay one yardstick flat on the ground. Place the compass in the middle. Be sure no steel tools, steel objects, or steel buildings of any kind are nearby, for they will affect the compass.

2. When the compass needle comes to rest, carefully turn the yardstick until it lines up with the needle of the compass. The stick and the head of the compass needle now are pointing towards magnetic north.

3. On the ground, drive in a nail with a patch of cloth on it, just beyond each end of the stick. If you are on an asphalt area, mark the end points with chalk.

4. Turn the compass slowly so that the needle points at 17° east of north. The N of the compass is now pointing towards true north, while the head of the swinging needle still points towards magnetic north. This difference between magnetic north and true north is called the "declination", and it is a different number of degrees for different places. The 17° East is the declination for Billings, Montana (see figure #1). A check of survey maps or air navigation maps of an area will give you the declination of that specific area.

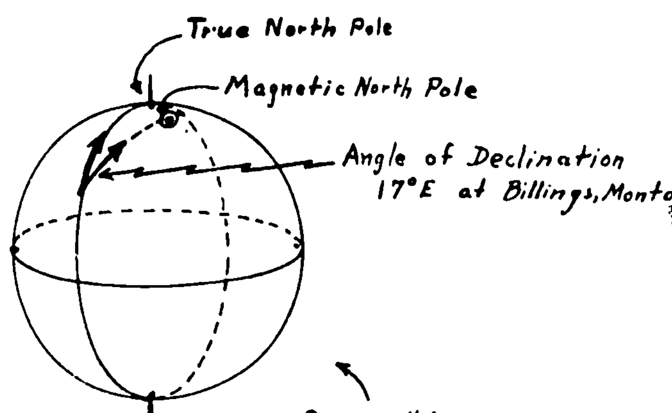


figure #1

5. Now carefully swing the stick so that it lines up with the N-S of the compass when the needle of the compass is pointing at 17° East of North. The stick now is pointing at true north.

6. On the ground, drive in a nail with cloth just beyond each end of the stick. This is the true north line.

7. Remove the compass, and lay the other stick across the true-north stick but at right angles (90°) to it. Use the square corner of the piece of Newspaper to get this 90° layout. Mark the end points of the stick (with nails or chalk).

8. Take up the two sticks, and using only one, draw straight lines from nail to nail through the center point of the two sticks. Put a nail with cloth at the center point. Your lines now should look somewhat like those shown in figure #2.

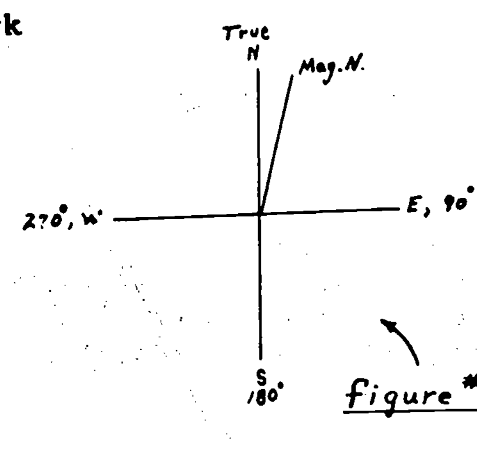


figure #2

9. Check the piece of newspaper to be sure it really is a square. Fold it on one diagonal,

so that it becomes a triangle. The two small angles of this triangle each are 45° angles.

10. Lay the longest side of the paper triangle along the north side of E-W line of the marks on the ground, with one sharp angle exactly at the center nail or mark (see figure #3).

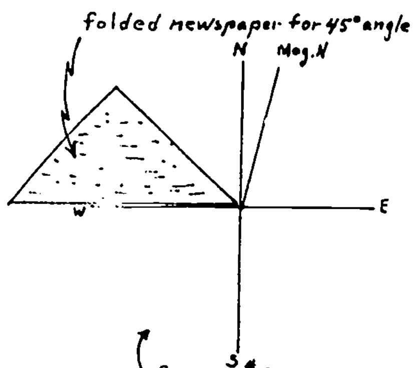


figure #3

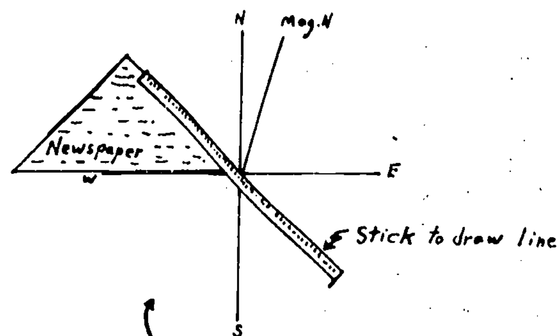


figure #4

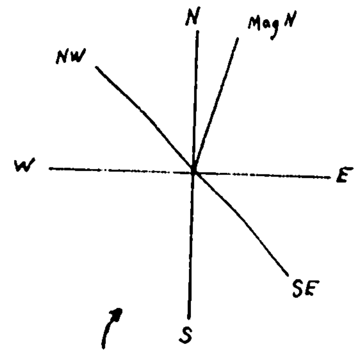


figure #5

11. Place a stick along the slanting edge and draw a line on the ground exactly along the slanting edge, through the center, and out the other side. You now have a line at 45° to the E-W line running from the 315° (or NW) point to the 135° (or SE) point (see figures #4 and #5).

12. Now flip the paper over the south side of the E-W line and draw a line along the slanting edge, through the middle. This runs between the 225° (or SW) point and the 45° (or NE) point. (See figures #6 and #7.)

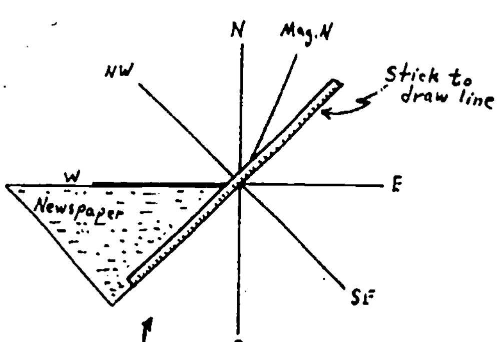


figure #6

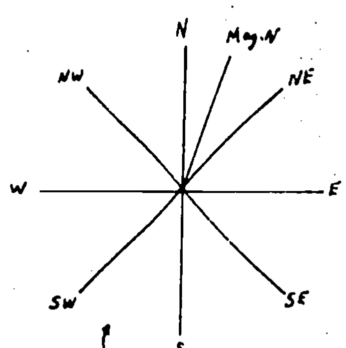


figure #7

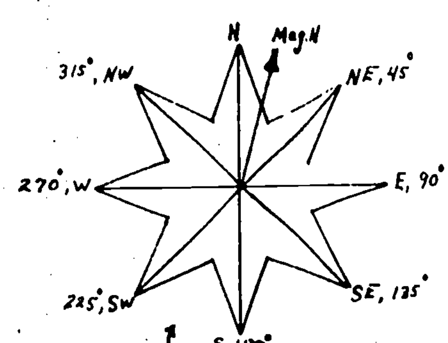


figure #8 A Compass Rose

13. You have now constructed all the points for a "compass rose". If you have done this on the asphalt playground of the school, ask the Principal if the compass rose can be painted, so it is there permanently for all students to use. Before painting, draw in other lines to give a solid figure as shown in figure #8.

Checking True North with the North Star:

The N-S axis of the world points at the North Star. That star is located by finding the Big Dipper in the sky. The two end stars of the Big Dipper are called the pointers. Let your eye travel in the direction they point, and the first

really bright star you see on that line is Polaris, or the North star (see figure #9).

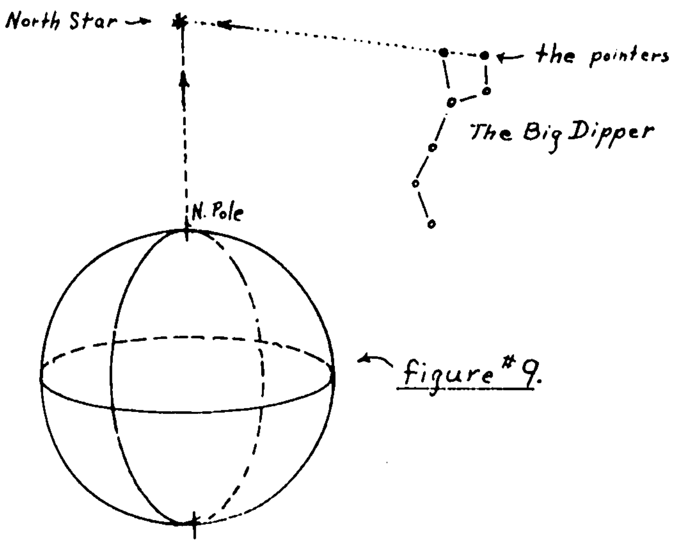


figure #9.

(Part B)

What to do to check true north:

1. On a clear night, set up a corner stake (see Skill #202) right at the center of your compass rose.

2. Put the pin of the Sighting Stick into the side hole of the corner stake.

3. Swing the sighting stick upward, and twist the corner stake until the sighting stick is aimed right at the north star (see figure #10).

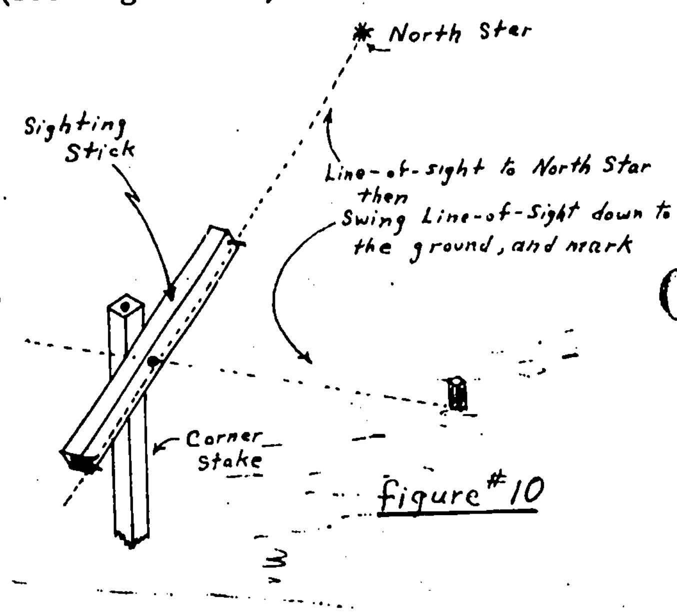


figure #10

4. Then carefully swing the sighting stick downward so that your line of sight hits the ground about 10 feet away from the compass rose. Have your partner (with a flashlight if need be) find the spot on the ground where your line of sight hits the ground. He should mark this point with chalk or with a nail.

5. Then (or next day), run a string from the center of the rose to the north star nail or mark. If your compass rose was laid out properly and carefully, the string should lie right on the true north line. If it does not, then there is an error in the Compass Rose.

Another way to do it, if you do not know the declination:

If you do not know the declination (the difference in degrees between true north and magnetic north), you could build the Compass Rose by (1) locating and marking the magnetic north line, as instructed in Part A, steps 1, 2, and 3; then (2) locate the true north line as instructed in Part B, steps 1 through 5. The angle difference between these two lines is the declination. Then, with a true north line established, go on as in Part A, steps 6 through 13, to develop the full Compass Rose. This method does not depend on your already knowing the declination -- and in fact would allow you to find that declination.

Litter, Litter Everywhere

Today we read in newspaper, magazines and books, see on T. V. and billboards and hear over the radio about the litter problem in our community. Really, how much litter is scattered around the areas where we work, play, and live? What is the composition? These are questions that are always being asked. You, as a famous environmentalist should never be satisfied with looking out the window and guessing at the answers to these questions. You must base your answers on quantitative data that you have collected.

Objectives

1. You will classify the litter found along transects in the study area.

2. You will measure both in quantity and weight of the various types of litter found along transects in the study area.

3. From data collected in a subsample, you will project this figure to the entire study area.

The Experiment

1. Select your study area. Try not to overlap study areas with other students. Vacant lots, rims, road ditches are excellent study areas because you will find a greater variety of litter.

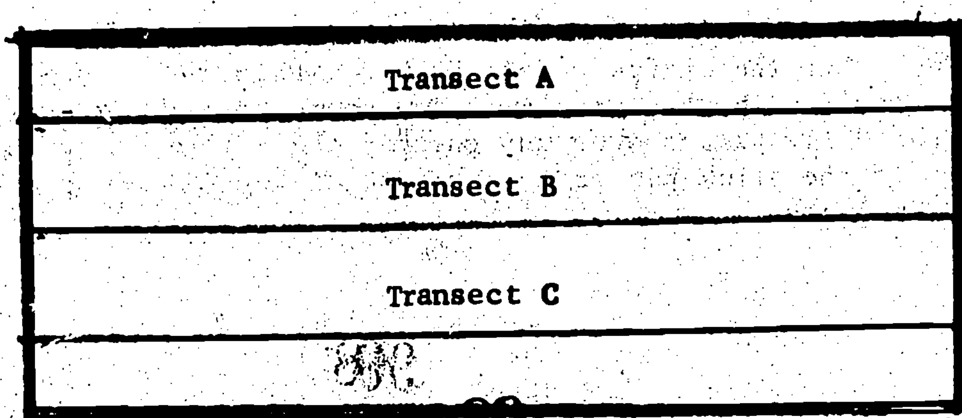
2. Once you select your study area, establish its limits. All you do is measure around the outside. Some study areas may be 2 or 3 meters wide and 100 meters long. Others may be 30 meters by 30 meters. A study area should have at least 100 m^2 area.

3. Draw a simple map of the study area and identify its location. Once you have completed this, let your instructor look it over and give you the OK to proceed.

4. You could go to your study area and collect all the trash. This is called whole sampling. Like all famous environmentalists you just don't have that much time so you will subsample and project this to the entire study area. One must be very careful in subsampling because of bias and error that may enter into the method. If your subsample figure is way off, your estimate of the amount of litter on the study area will also be in error.

5. One common method of sampling is known as the line or transect method. In any study area you try to see up at least three lines or transects. This way you can compare the differences between your samples. Your transect lines will usually run at right angles to one side of your study area.

Study Area

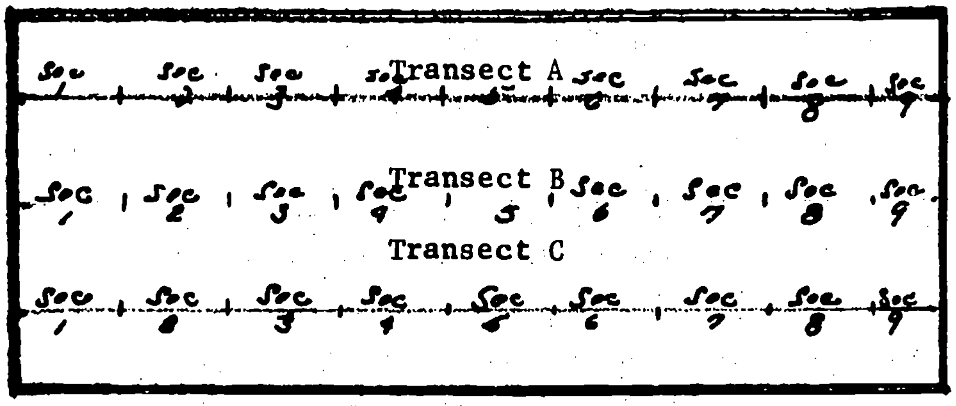


After you have established the transect lines you may subsample along the line. The most common method is to subsample every other five meter sections. Remember you must keep every subsample separate from all the others and also record the transect number. Be sure and label your samples.

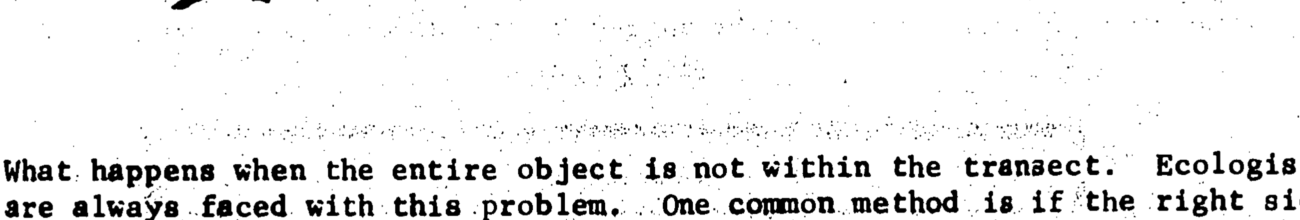
Transect
1
Section
2

By using this method you can calculate changes along a transect line.

Study Area



6. How wide a strip do you collect the litter? The best method in litter collecting is to take a meter stick and hold the middle of the stick directly over your transect line. Now collect every item that is under the stick. Now our transect line is one meter wide.



What happens when the entire object is not within the transect. Ecologists are always faced with this problem. One common method is if the right side of the meter stick passes over any part of the litter it is included in the sample but if the stick passes over a part of the litter or the left side it is not included.

7. When you come in from your study area you will have a bag containing litter from each subsample along each transect line.

8. Bring your box containing the bags of litter to school. Now you must classify the litter. Classify them into broad categories such as paper, cans, etc. Try to keep your classification system to five categories or less. List the categories on your data sheet.

   From your data determine the average # of pieces of litter per meter and the average weight per meter. Next calculate the total amount of litter in the study area by multiplying the average weight per meter times the area in meters^2 at the study area.

Data Sheet
Litter, Litter Everywhere

Transect #
Categories of Litter

Section #	1 #	2 weight	3 #	4 weight	5 #	6 weight	7 #	8 weight	9 #	10 weight
1										
2										
3										
4										
5										
Total										

Transect #

1										
2										
3										
4										
5										
Total										

Transect #

1										
2										
3										
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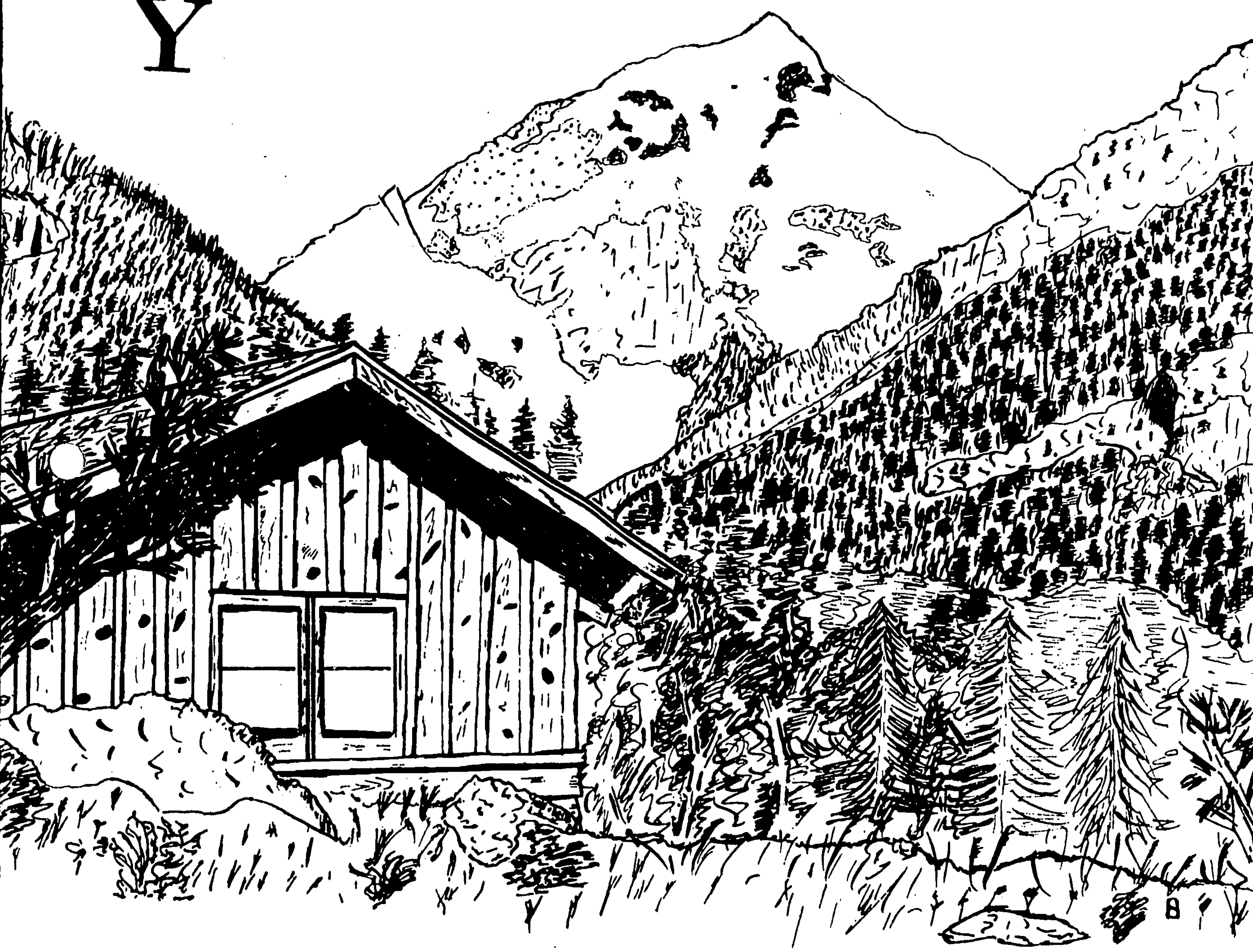
5										
Total										

K TO THE WOODY PLANTS
E THE BEARTOOTH MTS.
Y



Georgia Frazier
Norman Schoenthal

PREFACE

The description of ecosystems and a key to the plants of the separate ecosystems of the Beartooth and Absaroka Ranges is a joint venture of the Custer National Forest and Eastern Montana College. The primary purpose is to develop a greater ecological understanding of these rugged and beautiful mountains. To understand the basic ecology requires one to know, "What is that plant?" The plants are the best indicators of an ecosystem and give clues to the changes that are taking place within an ecosystem. Every attempt was made to avoid technical language so far as possible for greater use by the public.

It is our hope that you find these majestic mountains even more fascinating on your next trip into these areas. The next time, instead of saying, "We were in a bunch of evergreen trees", you can explain, "We were in a subalpine ecosystem", and "Weren't the purple cones of subalpine fir beautiful?"

We would like to express our thanks to the many people that gave so unselfishly of their time and talents in the development of this publication, including the U. S. Forest Service. A special thanks must be given to Phil South for his counsel and major contribution to the manuscript.

Georgia Frazier

Norm Schoenthal

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INTRODUCTION

The Beartooth and Absaroka Ranges are majestic and rugged mountains located in south central Montana, southwest of Billings. These ranges form a block, roughly rectangular in outline 80 miles long and 30 to 40 miles wide. Yellowstone Park and the Clarks Fork River in Northern Wyoming form the southern border. A line from Red Lodge, Big Timber to Livingston forms the Northern border. These two ranges which lie side by side differ in many respects and will be described separately.

The Beartooth Range is extremely diverse in topography and landform. Elevations vary from Granite peak, the highest point in Montana (12,799 feet), to approximately 5,000 feet in the lower Stillwater drainages. This range is an uplifted fault block. The Beartooth uplift has the form of a large asymmetric anticline with its overthrust into the Big Horn Basin to the east, according to Spencer in his article "The Geological Evolution of the Beartooth Mountains". This high flat plateau or peneplane has been greatly modified by subsequent erosion and glaciation. Reminents of these glaciers, now stagnant or retreating, are still present at the head of many valleys. Spectacular canyons have cut the original peneplane into five major plateau segments including Beartooth, Line Creek, Hellroaring, Silver Run, and East Rosebud Plateaus. The core of this uplifted block is composed of Pre-Cambrian granite, which means that this rock is extremely old. South of Granite Peak is the Beartooth Plateau, which differs from the other plateaus in that it is at a lower elevation and very flat and less modified. This plateau contains 100's of lakes including Kersey, Fox, Widewater and Granite.

The Absaroka Range in contrast is much more gentle than the Beartooth range. Streams have a greater tendency to meander down broad valleys and the intervening slopes are more rounded. Soils are deeper and vegetative cover is more prevalent. This range has much greater diversity in soils. Limestone, sandstone and basalt form the soils origins. Volcanic activity during the Tertiary period can be observed throughout the area.

The climate of the Absaroka and Beartooth Ranges is similar to that of the Rocky Mountain region and is locally controlled by the altitude. The climate at the higher elevations approaches that of the subartic, while the low elevation basins and valleys below 6,000 feet have a climate that may be classified as approaching semiarid.

Average annual precipitation for the area varies from less than 20 inches to over 70 inches. One-third to one-half the annual precipitation falls in April, May and June at the lower elevations, June being the wettest month. The period of least precipitation at the lower elevations is from November through March. These five months normally produce only about 25% of the year's precipitation. Rain squalls are very common during the summer months in the higher elevations. Snow from one to two feet up to nine feet in depth accumulates throughout the winter in this area. Snow seldom accumulates to great depths on the ground at lower elevations because of the occurrence of thawing periods "chinooks" during the winter. In areas of steep canyons and heavier snowfall, avalanches are common. Distribution and vegetation in many areas is limited by avalanche activity. At elevations above 9,000 feet it is possible that as much as 90% of the average annual precipitation is in the form of snow.

Average annual temperature for the low elevations is about 42° F, while that of the alpine (approximately 10,000 feet elevation) is estimated at 30° F. As a general rule, the temperature decreases about 1 to 2° F per each 500 feet elevation increase. Frost free days at the lower elevation generally fall between June and mid-September. Freezing temperatures may occur at any time at elevations above 7,500 feet. Wind direction is predominantly from the west, as is the main source of moisture. Wind is an important environmental factor in the alpine regions. Winds of 30 mph are common with speeds in excess of 50 mph occurring. These high wind velocities greatly increase the evaporation rates at high altitudes. Wind speeds increase during the winter months. Wind velocities decrease at lower elevations.

These physical and chemical parameters regulate the type of vegetation one finds in the Beartooth and Absaroka Ranges. A study conducted by the U.S. Forest Service separates 17 separate units which will be referred hereafter as ecosystems.

An ecosystem is a complex of living (biotic) and non-living (abiotic) components, each interacting with the other to function as an integrated system or unit. While each of the individual components has its own significance, it is the combined effort of all and the integration among them that is important. It is this total complex, rather than the individual components that governs production possibilities and use limitations. All descriptions and keys are based on these separate ecosystems.

Identification of Plants

The purpose of a "key" is to enable a person to distinguish one plant from another, based on a selection of characteristics. In practice a key divides the plants into large groups and by each additional step in the key into smaller and smaller groups and finally separates one plant from all other plants in the Beartooth and Absaroka Ranges. At each point in the key you must make a decision into which category of the alternative choices the plant in question falls. The opposing statements always are numbered alike but are lettered differently, eg., la. or lb. When the choice has been made you will find a number near the right hand margin that directs you to your next choice. You continue until you have identified the particular plant. To understand the terms used, consult figures 2 and 3 and the glossary of terms on pages 7, 8, and 9.

Never guess at meanings because this may result in making a wrong choice. Always read both choices carefully, for although the first choice sounds good, the second may be even better.

Once you have arrived at your final selection, look at the drawing to make sure your unknown plant corresponds and then read the more complete description located in the block directly below the name of the plant. Common names are given with the description, but it must be remembered that common names vary from place to place and even in these ranges. The same plant may go by two or three different names. The authors have taken the liberty to use the one most commonly used. The Latin or scientific name of each plant species appears below the drawing. It consists of two words used together, the genus name followed by the species name. These names are constant for a particular plant and understood by scientists throughout the world.

For those persons who are interested in the flora of this area and wish to get further information, the following publications will be useful:

Baerg, Harry J., 1955. How to Know the Western Trees. Wm. C. Brown Co.

Booth, W. E., 1950. Flora of Montana, Part 1, Gymnosperms and Monocots. Endowment-Research Foundation, Mont. St. University, Bozeman, Montana.

Booth, W. E. and J. C. Wright, 1966. Flora of Montana, Part 11, Dicotyledons. Dept. Botany and Microbiology, Mont. St. University, Bozeman, Montana.

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Craighead, J. J., F. C. Craighead, Jr., Ray J. Davis, 1963. A Field Guide to Rocky Mountain Wildflowers. Houghton Mifflin Co., Boston.

Hitchcock, C. Leo, Arthur Cronquist, Marion Ownbey, and J. W. Thompson; 1955, 1959, 1961, 1964, 1970. Vascular Plants of the Pacific Northwest, Vol. 17. University of Washington Publications in Biology.

McDougall, W. B., Herma A. Baggley, 1956. The Plants of Yellowstone National Park. Yellowstone Library and Museum Association.

Morris, M. S., J. E. Schmautz, P. F. Stickney, 1962. Winter Field Key to the Native Shrubs of Montana. Montana Forest and Conservation Experiment Station, Montana State University and Intermountain Forest and Range Experiment Station, Forest Service, U. S. Department of Agriculture.

Shaw, Richard J., 1964. Trees and Flowering Shrubs of Yellowstone and Grand Teton National Parks. The Wheelwright Press.

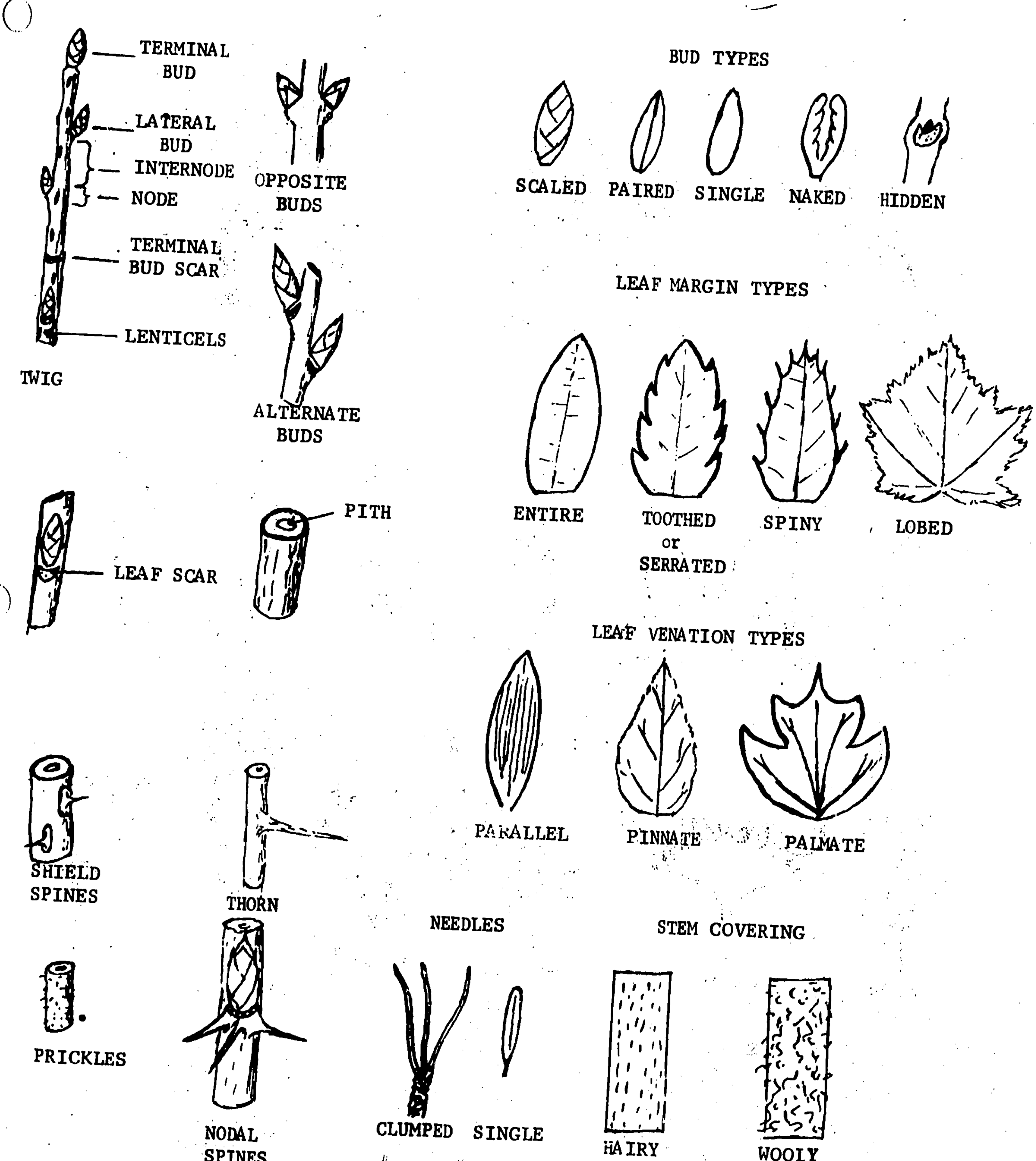
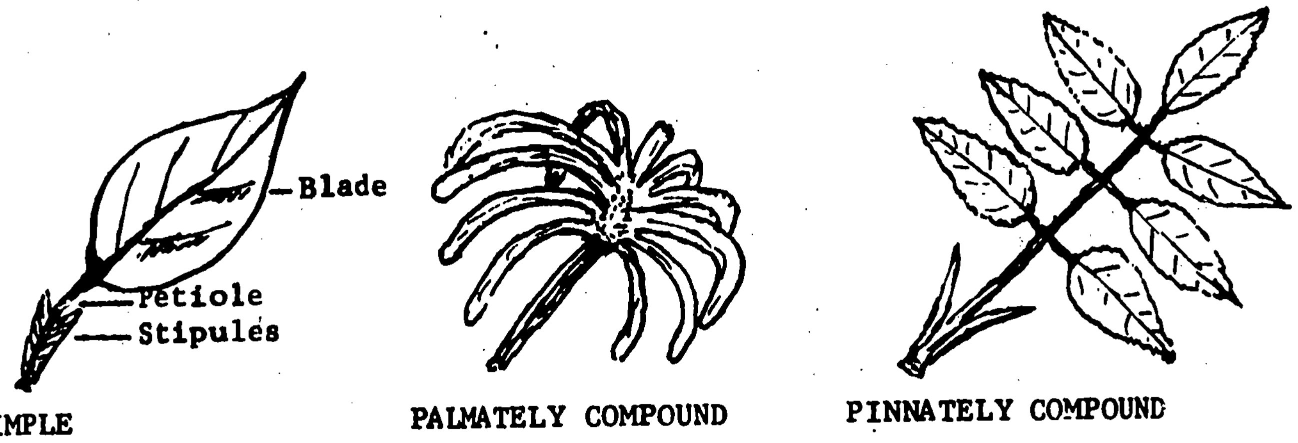
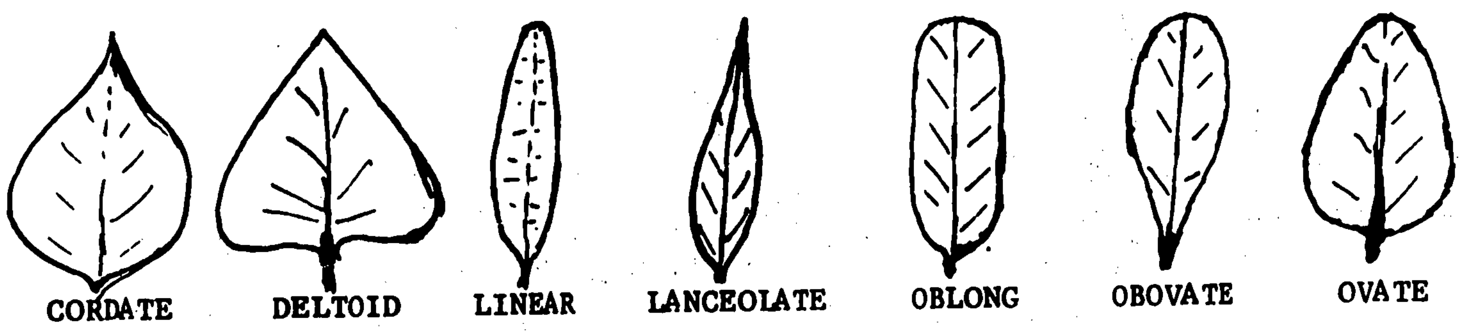


Fig. 2, Illustrations of plant characteristics used in the key.

LEAF CHARACTERISTICS



LEAF SHAPES



TYPES OF INFLORESCENCE

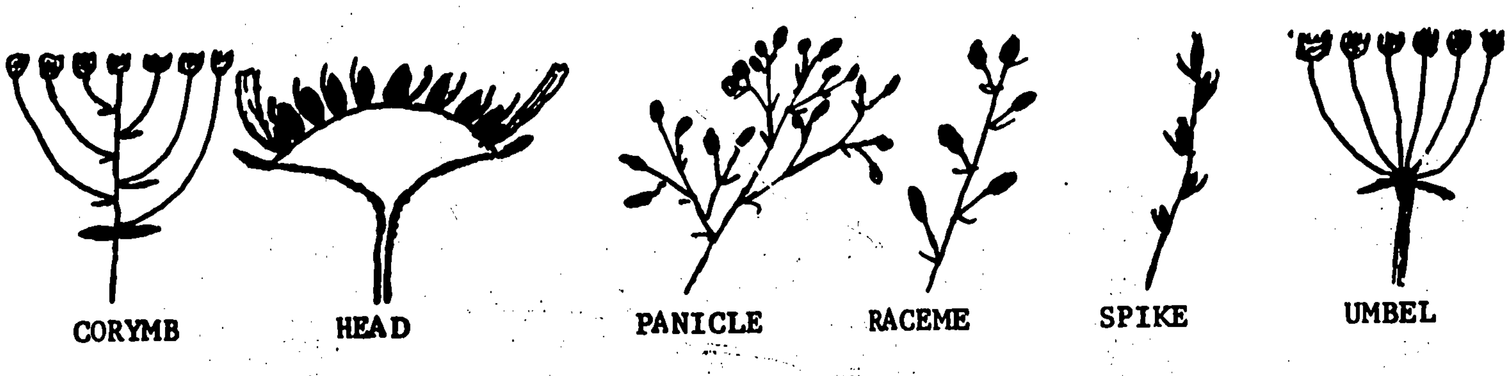


Fig. 3, Illustrations of plant characteristics used in the key.

GLOSSARY

ACUTE: Sharp pointed.

ALTERNATE: Arrangement of buds and leaves on a stem in which they occur singly at a node.

ANNUAL: A plant that completes its life span within one year.

ARMED BRANCHLETS: A modified branch that forms a sharp point containing buds, leaf scars, or fruit scars.

AWL-SHAPED: Narrow and gradually tapering to a sharp point.

AXIL: The inner or upper angle formed by the leaf and stem.

AXILLARY: Occuring in an axil.

BLADE: The expanded portion of a leaf.

BRACT: A modified leaf, usually subtending a flower or flower cluster.

BUD SCALE: A modified leaf forming part of the protective covering of a leaf bud.

BUNDLESCAR: Marks indicating the broken ends of vasular bundles (veins) variously arranged on a leaf scar.

CATKIN: A deciduous scaly flower or fruiting stalk (Fig. 1, inflorescence.)

COMPOUND: Leaf type which consists of more than one flat surface. These leaflets are attached to a central axis (petiole) which in turn attaches them to the twig.

CORYMB: Floral arrangement which is more or less flat-topped, the outer flowers opening first.

CYME: Floral arrangement that is flat-topped, the inner or central flowers blooming first.

DECIDUOUS: Falling off at the end of a growing season; not permanent or evergreen.

DELTOID: Triangular-shaped.

DISSECTED: Deeply and finely cut or lobed into many divisions.

ENTIRE: The margins not at all toothed, lobed or divided.

EVERGREEN: Leaves remaining on stem through winter in green condition.

FIBROUS: Having many woody fibers. Common in the bark of some shrubs forming long, free, stringy strands on the stem.

GLABROUS: A smooth surface, free of hairs or scurfy material.

GLANDULAR: Surface containing minute glands.

HAIRY: Scattered, loose epidermal hairs on stem, leaf or bud surfaces.

INFLORESCENCE: The flowering part of the plant, especially the arrangement.

INTERNODE: The part of a stem between two nodes.

INVOLUCRE: A set of bracts surrounding or just below a flower cluster.

LANCE-SHAPED: Tapering at both ends, with the widest part below the middle.

LATERAL: Borne on the sides.

LEAF BASE: That portion of the petiole (leaf stalk) remaining attached to the stem after the leaf has fallen or is broken off.

LEAFLETS: The individual flattened leaf surfaces which make up a compound leaf.

LEAF SCAR: The surface structure on the stem remaining after the fall of a leaf.

LENTICEL: Wart-like, usually light colored spots on the bark of twigs.

LINEAR: Narrow and nearly uniform in width.

LOBES: Segments of a leaf produced by indentation of leaf margin as illustrated in maples.

MIDRIB: The central or main rib of a leaf.

NAKED: Usually refers to buds which lack typical bud scales.

NODE: A place on a stem where a leaf is borne.

OBLONG: Two or three times as long as broad, more or less elliptic.

OPPOSITE: An arrangement of buds or leaves paired on opposite sides of the stem at a node.

OVATE: Egg-shaped with the broadest part downward.

PALMATE: Arising from a common base, as the leaflets of some compound leaves or the veins of some leaves.

PANICLE: A compound, open flower cluster like a branched raceme.

PINNATE: Arrangement of parts along two sides of an axis.

PETIOLE: The portion of the leaf (particularly broad-leaved plants) which attaches the flat part of the leaf to the twig.

PRICKLE: Synonymous with spines; small sharp-pointed outgrowths of the bark.

PROSTRATE: Lying flat upon the ground.

RACEME: An open flower cluster with stalked flowers arranged along an axis.

SCURFY: A scaly textured surface on leaves and stems.

SESSILE: Without a petiole or stalk.

SHEATH: A more or less tubular structure enveloping another structure, usually a stem.

SPIKE: A flower cluster like a raceme but with the flowers sessile.

SPINES: Short, thorn-like structures common in roses and currants.

STIPULES: Paired appendages borne at the base of the leaf stem; deciduous in most species, leaving a mark above and to one side of the leaf scar.

SUNKEN: Describes a bud that appears to be partially or completely below the surface of the stem or leaf scar.

TENDRILS: Slender threadlike structures by which vines attach themselves to a support.

THORN: Large sharp-pointed, developed from a stem and containing stem tissue; but not easily broken or bent.

TOOTHED: The margin of leaves notched or cut to form a sawlike edge.

VALVATE: Paired outer bud scales with margins touching and wholly enclosing the bud.

UNBEL: A flat-topped flower cluster with the flower stalks all attached at the sand-level, like the ribs of an umbrella.

WHORLED: Arrangement of leaves or other organs at a node.

WHERE AM I?

LODGEPOLE PINE ECOSYSTEM
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STREAMSIDE HARDWOOD ECOSYSTEM
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ASPEN ECOSYSTEM
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ROCK OUTCROP-FOREST ECOSYSTEM
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LODGEPOLE PINE ECOSYSTEM

This ecosystem is located on the bottom and sides of broad, U-shaped glaciated valleys in the lower elevations up to 8,000 feet. This ecosystem is usually found on very skeletal soil derived from unassorted glacial till. Very rarely is it found on soils derived from limestone.

The soil in this ecosystem is 30 to 100 cm deep, well drained, very stony and gravelly with a thin organic surface of twigs and needles. Dense thickets of lodgepole pine have very little understory vegetation, with only a mat of needles and twigs covering the ground. The more open stands contain an understory of mainly low red huckleberry.

This ecosystem is not as rich as the other forest ecosystems. Wildlife species consist mainly of insect eating birds and some rodents. Elk and moose use the low red huckleberry for food and the timber for cover, especially in late summer and fall. Blue grouse are found in the fall, while bear forage on the huckleberries when they are ripe.

Plant succession in this ecosystem ends in a lodgepole climax. Progression to a Douglas fir climax does not occur because of the limits of productivity from sterile glacial soils. In many cases, "dog hair" of densely growing trees which have stagnated is a result of fires. Fires occuring periodically would only tend to re-establish new stands of lodgepole and whortleberry. Lodgepole pine also has the greatest transpiration rate of all the conifers in this area.

KEY
TO THE COMMON PLANTS OF
THE LODGEPOLE PINE ECOSYSTEM

1a. Woody plants, maybe only woody at base. (2)

1b. Plants herbs, dies annually, at least down to the ground.

2a. Tree like, one central stem, evergreen, with needle-like leaves. Needles in bundles of two.

LODGEPOLE PINE

Needles 2½ - 7½ cm long; lopsided cones with sharp spines. Grows in dense stands, losing the lower branches as they become shaded. Cones often remain closed for many years. Heat of a fire usually will cause them to open and reseed the area.

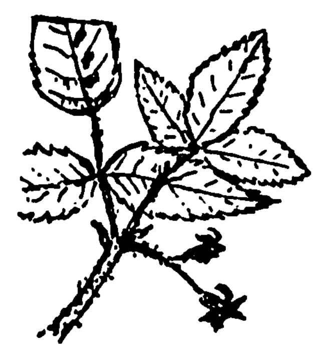
LODGEPOLE PINE
(*Pinus contorta*)

2b. Shrub-like, more than one central stem, less than 3 meters in height. (3)

3a. Stems with spines or prickles less than ½ cm in length; leaves compound, white underneath.

RASPBERRY

Three to five leaflets, doubly serrate, glabrous above, white woolly hair below. Erect stems are prickly. White flowers about 2 cm across or less, fruits a light red, and sweet.



RASPBERRY
(*Rubus idaeus*)

3b. Stems without spines or prickles. (4)

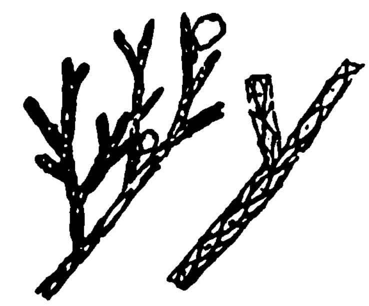
4a. Leaves awl-shaped, or scale-like; blue berry like fruit usually present. (5)

4b. Leaves not awl-shaped or scale like, broad leaf. (6)

5a. Leaves scale-like, 4 ranked, pressed to the stem.

ROCKY MOUNTAIN JUNIPER

A tall shrub or small tree up to 12 meters in height. The branches are long and drooping. The seed is berry-like, small, smooth and green or bluish. The trunk is short and stout, often divided near the ground. The wood of these trees is soft and durable and is used primarily for fence posts.



ROCKY MOUNTAIN JUNIPER
(*Juniperus scopulorum*)

5b. Leaves awl-shaped, or spiny, with a white line on one surface, in whorls of three.

COMMON JUNIPER
(Juniperus communis)

COMMON JUNIPER

Low, spreading shrub which forms dense patches on the ground 6 - 9 dm in depth. Leaves are arranged in whorls of 3. See cones (berries) are 12 mm in diameter, green becoming dark blue with a bloom. Junipers play an important part in Indian ceremonials and legend and as a source of medicine, food, and dye.

6a. Plants with deciduous leaves, bud usually found at the axis of petiole and stem. (7)

6b. Plants evergreen, bud not found at the axis of the petiole and the stem. (9)

7a. Leaves or buds opposite. Stems hollow; fruits or flowers in irregular clusters of several to many.

SNOWBERRY
(Symphoricarpos albus)

SNOWBERRY

Erect shrub, 20 - 80 cm tall; leaves short-petioled, opposite, oval to egg-shaped, entire or somewhat sinuate. Flowers white or pinkish in crowded clusters in leaf axils and ends of branches. Petals form corolla tube. Berries white, two seeded, eaten by many kinds of birds.

7b. Leaves or buds alternate. (8)

8a. Leaves smooth edged, buds valvate; young twigs angled or winged, ending in a broom of small branches, low plants 15 to 30 cm high.

LOW RED HUCKLEBERRY
(Vaccinium scoparium)

LOW RED HUCKLEBERRY

Also called Whortleberry. Low, tufted shrub 1 - 4 dm high. Flowers solitary in the axils of the stems. Corolla light or dark pink, berries are bright pink. Bears are fond of the berries, as also are birds and people.

8b. Leaves toothed, ovate-oval, 2 to 4 cm long teeth large, 4 or 5 per inch.

SPIREA

Leaves ovate-oval, 2 - 4 cm long, finely serrate at least ½ their length. Bright green on upper surface, paler and strongly veined beneath. Bark reddish or purplish brown. Petals pink to rose.

SPIRAEA
(*Spiraea densifolia*)

9a. Leaves toothed, holly-like; plants growing next to ground.

OREGON GRAPE

Low shrub from underground rootstocks. Leathery leaves have 3 holly-like leaflets with 10 or more small teeth. Flowers bright yellow, fruit dark blue, pear-shaped. State flower of Oregon.

OREGON GRAPE
(*Berberis repens*)

9b. Leaves oblong, 1 - 2 cm in length; low creeping shrub.

KINNIKINNICK

Main stem prostrate, forming mats. Leaves are 1-2 cm long, leathery, round to subacute at tip. Flowers bell-shaped, white or pink, in short few-flowered racemes. Bears, Mountain Sheep, deer and birds eat the red fruits; bark and leaves of the plant were dried and smoked in place of tobacco.

KINNIKINNICK
(*Arctostaphlos uva-ursi*)

DOUGLAS FIR ECOSYSTEM

This ecosystem is located on the bottoms and sides of glaciated valleys in the lower elevations up to 8,000 feet. At lower, warmer, and drier elevations this ecosystem is confined to north-facing slopes and shaded areas. At higher elevations it occurs on sunny slopes and drier exposures than where Engelman spruce and alpine fir can be found.

This ecosystem is dependent on humus-enriched soils, low surface temperatures, and partial shading for establishment. Best development occurs on soils of limestone and granite origin. Soils are generally 30 to 150 cm in depth, contain less rock in surface horizons, and have a thicker organic mat than soils of lodgepole pine ecosystems. Factors which cause a change in the humus layer, soil surface temperature, moisture, and shade affect the maintenance of this ecosystem. High intensity fires may reduce the potential so that lodgepole pine is dominant for a long period of time, but controlled fires may be necessary to maintain certain aspects of the ecosystem.

Three distinct variations of this ecosystem occur in the Beartooth and Absaroka Ranges based on understory vegetation. These are the Douglas-fir ninebark variation is more prevalent on moist sites and at lower elevations. It may be confined to northern slopes because of moisture requirements. Douglas-fir snowberry and Douglas-fir huckleberry variations also occur.

When overstory vegetation is Douglas fir, plant succession is near climax. This ecosystem occurs on relatively fertile soils and rates high in both forest and animal production. Characteristic of this ecosystem is the great variety of songbirds that inhabit the edges of the ecosystem. Most big game species may be found during some season of the year. This is winter range for moose, elk, and deer. In rocky areas, bighorn sheep may also be found. Bears hibernate here, and many small rodents are permanent residents.

KEY
TO THE COMMON PLANTS OF
-THE DOUGLAS FIR ECOSYSTEM-

1a. Woody plants, may be only woody at base (2)

1b. Plants are herbs, die annually, at least down to the ground.

2a. Tree like, one central stem, usually greater than 3 meters in height. (3)

2b. Shrub like, more than one central stem, less than 3 meters in height. (4)

3a. Tree has needle-like leaves, narrowed at base; cones hang downward. Cones have prominent 3-pointed bract.

DOUGLAS FIR

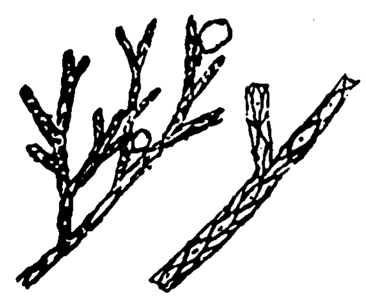
The flat needles are borne singly and grow around the branch giving it a full appearance. "Neptune's tridents", the three-pronged bracts between the cone scales, are found in both immature and mature cones. The bark is gray-brown with resin blisters in young trees becoming deeply grooved gray-brown cork-like in older ones. A very valuable lumber tree and also used as Christmas trees.

DOUGLAS FIR
(*Pseudotsuga menziesii*)

3b. Tree has scale-like leaves, 5 mm or less in length. The seed is berrylike.

ROCKY MOUNTAIN JUNIPER

A tall shrub or small tree up to 12 meters in height. The branches are long and drooping. The seed is berrylike, small, smooth and green or bluish. The trunk is short and stout, often divided near the ground. The wood of these trees is soft and durable and is used primarily for fence posts.



ROCKY MOUNTAIN JUNIPER
(*Juniperus scopulorum*)

4a. Plants evergreen, bud not found at the axis of the petiole and the stem. (5)

4b. Plants not as above, leaves deciduous, bud usually at the axis of the petiole and stem. (7)

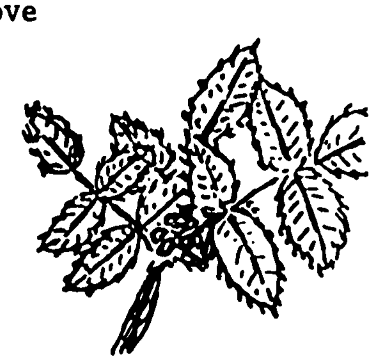
5a. Leaves scalelike, 5 mm or less in length. Fruit a blue berry. (3b) above

5b. Leaves not scalelike, broad-leaved plants. (6)

6a. Leaves toothed, holly-like; plants growing next to the ground.

OREGON GRAPE

Low shrub from underground rootstocks. Leathery leaves have 3 holly-like leaflets with 10 or more small teeth. Flowers bright yellow, fruit dark blue, pear-shaped. State flower of Oregon.



OREGON GRAPE
(*Berberis repens*)

6b. Leaves oblong, 1 - 2 cm in length; low creeping shrub.

KINNIKINNICK

Main stem prostrate, forming mats. Leaves are 1-2 cm long, leathery, round to subacute at tip. Flowers bell-shaped, white or pink, in short few-flowered racemes. Bears, Mountain sheep, deer and birds eat the red fruits; bark and leaves of the plant were dried and smoked in place of tobacco.

KINNIKINNICK
(*Arctostaphles uva-ursi*)

7a. Stems with spines or prickles; fruits usually several in a cluster; petals 1.5 - 2.5 cm long; spines arising below the leaf scar stout and paired.

WOODS ROSE

Sepals 5, petals 5, rose-colored inflorescence a few-flowered cyme. After the petals fall, the pistils and their cup-like receptacle become a rose "hip", which provides food for wildlife.

WOODS ROSE
(*Rosa woodsii*)

7b. Stems without spines or prickles (8)

8a. Leaves or buds opposite. (9)

8b. Leaves or buds alternate. (10)

9a. Stems hollow; fruits or flowers in irregular clusters of several to many; bundle scars 1.

SNOWBERRY

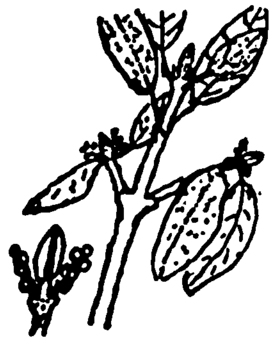
Erect shrub, 20 -80 cm tall; leaves short-petioled, opposite, oval to egg-shaped, entire or somewhat sinuate. Flowers white or pinkish in crowded clusters in leaf axils and ends of branches. Petals form corolla tube. Berries white, two seeded, eaten by many kinds of birds.

SNOWBERRY
(*Symphoricarpos albus*)

9b. Stems not hollow; leaves spotted beneath with brownish scales.

CANADIAN BUFFALOBERRY

Shrub 1 to 3 m high; opposite leaves. Flowers yellowish, appear in June, are inconspicuous as the petals are missing. Red-orange berries appear in August. They are very bitter, but are a source of food for wildlife.



CANADIAN BUFFALOBERRY
(*Shepherdia canadensis*)

10a. Buds valvate; leaves smooth edged, or toothed under magnification. (11)

10b. Buds not valvate; leaves toothed or lobed. (12)

11a. Young twigs angled or winged, ending in a broom of small branches, stems green; low plants - ½ to 1 foot high, leaves ½ inch long or less.

LOW RED HUCKLEBERRY

Also called Whortleberry. Low, tufted shrub 1 - 4 dm high. Flowers solitary in the axils of the stems. Corolla light or dark pink, berries are bright pink. Bears are fond of the berries, as also are birds and people.

LOW RED HUCKLEBERRY
(<u>Vaccinium scoparium</u>)

11b. Plants 1 to 4 feet high, stems not ending in a broom of fine branches; leaves close to 1 inch long, or longer, more than 1½ times longer than wide; some stems reddish.

THINLEAF HUCKLEBERRY

Erect branching shrub 1 - 2 m high. Flowers solitary in the axils, yellowish. Berry is dark wine-colored or purplish black, and edible. In winter there is a short projection of stem tip beyond the apparent "terminal"bud. True terminal bud is missing.

THINLEAF HUCKLEBERRY
(<u>Vaccinium membranaceum</u>)

12a. Leaves not lobed, only toothed, ovate-oval, 2 - 4 cm long, teeth large, 4 or 5 per inch.

SPIRAEA

Leaves ovate-oval, 2 - 4 cm long, finely serrate at least ½ their length. Bright green on upper surface, paler and strongly veined beneath. Bark reddish or purplish brown. Petals pink to rose.

SPIRAEA
(<u>Spiraea densifolia</u>)

12b. Leaves almost always 3 palmately lobed, doubly toothed, 4 to 8 cm long. Older stems gray, shreddy, revealing light-colored innerbark.

NINEBARK

Shrub .5 to 2 m tall. Leaves green above, pale beneath, 4 - 8 cm long, usually 3 palmately lobed and doubly toothed. Petals usually white, stamens 20 - 40, Inflorescence in terminal corymb.

NINEBARK
(<u>Physocarpus malvaceus</u>)

GRASSLAND ECOSYSTEM

This ecosystem occurs on the gently sloping or rolling foothills below the forest ecosystem where moisture is insufficient to support tree cover. Upper altitudinal limits vary from 6,500 feet on north slopes to 7,500 feet on south slopes.

Soil of this ecosystem is moderately deep, has a thick, dark surface horizon enriched in humus, and is not as acid as alpine soils. Soils are derived from limestone materials or glacial deposits. Included in the horizon is a considerable amount of gravel and rounded stones.

The grassland ecosystem can be subdivided into two communities, Bunchgrass-forb Grassland Ecosystem and the Bunchgrass-sage Grassland Ecosystem. The bunchgrass-forb has soils derived primarily from limestone materials, while the bunchgrass-sage is found on soils developed over glacial deposits. The latter is better drained and represents a drier site than the bunchgrass-forb.

The grassland ecosystem is a key winter range for elk and in some locations, bighorn sheep. The sagebrush variation provides winter range and the first green forage in spring for deer. Sharptail grouse, blue grouse, and sage grouse use this area for brood and winter range. Coyotes, bobcats, badgers, eagles, hawks, and owls all hunt this area for rodents.

The grassland ecosystem rates high for both animal habitat and low vegetation. They also have a drier climate and higher water losses than other ecosystems. The vegetative cover is important in decreasing evaporation from the soil, increasing infiltration, and preventing erosion. When the grassland ecosystem receives heavy use it greatly affects the infiltration rates, the vegetative cover is decreased, resulting in more surface runoff, increased erosion, and drier site.

KEY
TO THE COMMON PLANTS OF
THE GRASSLAND ECOSYSTEM

1a. Woody plants, may be only woody at base (2)

1b. Plants herbs, dies annually, at least down to the ground

2a. Tree like, one central stem, usually greater than 3 meters in height. (3)

2b. Shrub-like, more than one central stem. Less than 3 meters in height. (4)

3a. Evergreen tree with needle-like leaves, needles in bundles of 5, cones 7 - 15 cm long, or longer.

LIMBER PINE

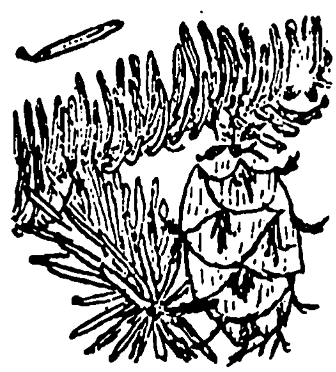
Usually a twisted and stunted tree from 10 to 15 meters tall. Bark is thin, smooth, light gray on younger trees, dark brown and plated on older Needles in clusters of five, 2½ to 3 cm long. Cones 1 - 1½ dm long, young branches exceptionally limber. This characteristic allows this plant to withstand severe winds.

LIMBER PINE
(Pinus flexilis)

3b. Evergreen trees with needle-like leaves that are single, not in bundles, flat, and narrowed at base; cones with prominent 3-pointed bracts, hang downward.

DOUGLAS FIR

The flat needles are borne singly and grow around the branch giving it a full appearance. "Neptune's tridents", the three-pronged bracts between the cone scales are found in both immature and mature cones The bark is gray-brown with resin blisters in young trees becoming deeply grooved gray-brown cork-like in older ones. A very valuable lumber tree and also as Christmas trees.



DOUGLAS FIR
(Pseudotsuga menziesii)

4a. Leaves awl-shaped, or scale-like; blue berry like fruit usually present

4b. Leaves not awl-shaped or scale like. (6)

5a. Leaves awl-shaped, or spiny, with a white line on one surface, in whorls of three.

COMMON JUNIPER

Low, spreading shrub which forms dense patches on the ground 6 - 9 dm in depth Leaves are arranged in whorls of 3. Seed cones (berries) are 12 mm in diameter, green becoming dark blue with a bloom. Junipers play an important part in Indian ceremonials and legend and as a source of medicine, food, and dye.

COMMON JUNIPER
(Juniperus communis)

5b. Leaves scale-like, 4 ranked, pressed to the stem.

ROCKY MOUNTAIN JUNIPER

A tall shrub or small tree up to 12 meters in height The branches are long and drooping. The seed is berry-like, small, smooth and green or bluish. The trunk is short and stout, often divided near the ground. The wood of these trees is soft and durable and used primarily for fence posts.

ROCKY MOUNTAIN JUNIPER
(*Juniperus scopulorum*)

6a. Leaves evergreen, with distinct odor of sage. (7)

6b. Leaves deciduous. (9)

7a. Leaf strap-shaped, tip entire (rounded) 3 - 7 dm in height.

SILVER SAGE

Shrub 3 - 7 dm high. Stems and leaves grayish with short hairs. Leaves narrow, sessile, usually entire flower heads numerous, 3 mm broad, glomerate or sometimes solitary in axils of leaves.

SILVER SAGE
(*Artemisia cana*)

7b. Leaves toothed or lobed at the end. (8)

8a. Leaves 5 to many lobed at the end, in crowded clusters, 2 - 3 dm in height.

FRINGED SAGE

From a slightly shrubby base, this plant is silky-hairy, silvery, 2 - 3 dm high. Stems simple or branched. Leaves mostly twice ternately divided into linear, crowded lobes. Flower heads numerous in an open panicle.

FRINGED SAGE
(*Artemisia frigida*)

8b. Leaves 3 lobed, larger plant than above, usually higher than 30 cm, bundle of very small leaves in leaf axil, ½ - 4 m in height.

BIG SAGEBRUSH

Gray-green shrub ½ - 4 m high, much branched; leaves 15 - 30 mm long, 3 - 7 toothed or lobed. Flower heads in dense panicles. Bark shreds into long strips. Flowers in August and September, a common cause of hay fever.

BIG SAGEBRUSH
(*Artemisia tridentata*)

9a. Leaves compound, leaflets mostly 3 to 5, rather strongly aromatic when crushed.

SKUNKBUSH SUMAC

Shrub 3 to 15 dm tall. Terminal leaflet 3 lobed and coarsely toothed, lateral leaflets smaller, scarcely lobed. Flowers yellowish, appearing before the leaves in short spike-like clusters. Fruit bright orange-red, flattened, sticky hairy.

SKUNKBUSH SUMAC
(Rhus trilobata)

9b. Leaves simple, palmately 3 to 5 lobed.

SQUAW CURRANT

Shrub ½ to 1½ m tall. Flowers are pink or white. Fruit is a red to orange berry. Young stems orange-brown with circular to irregularly shaped, resinous, transparent to white dots. Fruit valuable for birds.

SQUAW CURRANT
(Ribes cereum)

STREAMSIDE ECOSYSTEM

This ecosystem occurs on the banks, level bottoms and flood plains along streams and rivers. This ecosystem extends downward from the subalpine ecosystem to the grassland ecosystem. It has the widest diversity of woody plants found in the Absaroka and Beartooth Mountains. There is also a wide variety of forbs and grasses. Vegetation along these streams is markedly different from that on the drier surrounding lands because of the permanent supply of water, which the vegetation uses directly from the stream or from the high water table near the stream.

In the lower elevations cottonwood dominates, but as you move to higher elevations the hardwoods are replaced by conifers, until you reach the subalpine where willow dominates the ecosystem.

The alluvial soil adjacent to the stream is moderately deep andusually rich in organic matter, mineral nutrients making these some of the most productive soil. The large numbers of hardwoods growing along the bank produce litter that is less acidic than in a conifer forest. This may influence the large number of shade tolerant forbs that is associated with this ecosystem.

The abundant and wide variety of plant life found in this ecosystem also supports a wide diversity of animals. This is particularly significant when one studies the insect populations of this ecosystem. Most fur-bearing animals are associated with this type. It also furnishes a great deal of the winter browse for the big game animals.

KEY
TO THE COMMON PLANTS OF
-THE STREAMSIDE ECOSYSTEM-

1a. Woody plants, may be only woody at base. (2)

1b. Plants are herbs, die annually, at least down to the ground.

2a. Tree like, one central stem; usually greater than 3 meters in height. (3)

2b. Shrub like, more than one central stem; less than 3 meters in height. (17)

3a. Evergreen, trees with needle-like or scale-like leaves (4)

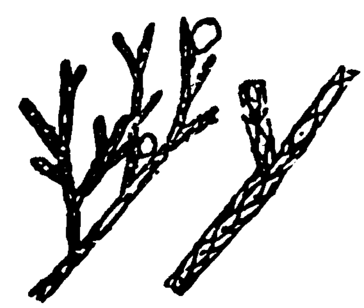
3b. Broad-leaved trees, not evergreen. (8)

4a. Plants with needle-like leaves, seed is formed in a cone. (5)

4b. Plants with scale-like leaves, 5 mm or less in length, seed is berry-like.

ROCKY MOUNTAIN JUNIPER

A tall shrub or small tree up to 12 meters in height. The branches are long and drooping. The seed is berrylike, small, smooth and green or bluish. The trunk is short and stout, often divided near the ground. The wood of these trees is soft and durable, and is used primarily for fence posts.



ROCKY MOUNTAIN JUNIPER
(*Juniperus scopulorum*)

5a. Needles single, not in bundles. (6)

5b. Needles in bundles of two.

LODGEPOLE PINE

Needles $2\frac{1}{2}$ - $7\frac{1}{2}$ cm long; lopsided cones with sharp spines. Grows in dense stands, losing the lower branches as they become shaded. Cones often remain closed for many years. Heat of a fire usually will cause them to open and reseed the area.

LODGEPOLE PINE
(*Pinus contorta*)

6a. Needles flat, hard to roll between fingers, usually soft to the touch. (7)

6b. Needles 4 sided, can be rolled between fingers; cone scales angular with fringed edges; needles sharp to touch.

ENGLEMAN SPRUCE

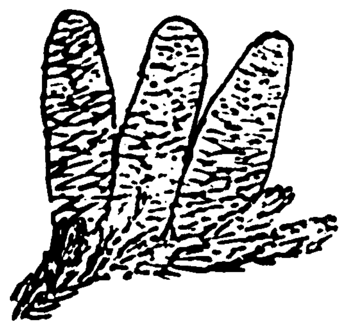
Cones have papery scales, are 4 - 7 cm long. Bark is thin, scaly, grayish red to purplish brown. Has a straight trunk with spreading and drooping branches in regular whorls forming a narrow spire.

ENGLEMAN SPRUCE
(*Picea engelmanii*)

7a. Needles not narrowed at base; cones point upward.

ALPINE FIR

Smooth gray bark of young trees is unique because of the many lens-shaped blisters. Seed cones are barrel-shaped, dark purple. As the result of heavy snows, the lower branches often become rooted forming a circle of smaller trees. Such a colony is called a snowmat.



ALPINE FIR
(Abies lasiocarpa)

7b. Needles narrowed at base; cones hang downward, cones with prominent 3-pointed bract.

DOUGLAS FIR

The flat needles are borne singly and grow around the branch giving it a full appearance. "Neptune's tridents", the three-pronged bracts between the cone scales are found in both immature and mature cones. The bark is gray-brown with resin blisters in young trees becoming deeply grooved gray-brown cork-like in older ones. A very valuable lumber tree and also as Christmas trees.

DOUGLAS FIR
(Pseudotsuga menziesii)

8a. Leaves or buds alternate (9)

8b. Leaves or buds opposite, small tree, many times shrub-like.

ROCKY MOUNTAIN MAPLE

Leaves are three to five lobed; plant is usually less than twelve feet in height. Twigs with dark red bark, older stems with smooth gray bark. In certain areas a tiny mite stimulates formation of brilliant red galls on the leaves.

ROCKY MOUNTAIN MAPLE
(Acer glabrum)

9a. Bark pale or light colored; pith star shaped; buds usually sticky, older trees over 10 meters high. (10)

9b. Bark dark colored; pith not star shaped; catkins usually present, older trees smaller. (13)

10a. Buds sticky with resin, buds greater than 1 cm in length (11)

10b. Buds not sticky; young twigs reddish-brown, shiny twigs.

QUAKING ASPEN

Leaf blades are round or heart shaped, ciliate on the margin. Long, flat petiole causes leaves to tremble with the slightest breeze. The tree often develops abundantly after a forest fire and forms dense groves, especially in moist places.

QUAKING ASPEN
(Populus tremuloides)

11a. Buds less than 12 mm in length; petioles (stem of leaf) flattened.

PLAINS COTTONWOOD

Grows to a large tree, sometimes 30 m tall. Leaves 5 - 10 cm long, broad, triangular; dark bark, thick rough-furrowed on older trees. Has a broad open crown and grows only where there is an abundance of soil moisture. Very common in the valley as you approach the Beartooth Mountains.

PLAINS COTTONWOOD
(Populus deltoides)

11b. Buds greater than 12 mm in length; petioles rounded. (12)

12a. Leaf blades whitish or gray beneath, sharply contrasted with upper green surface; twigs greenish-orange; terminal buds plump.

BLACK COTTONWOOD

Has large broadly ovate leaves which are up to 12 cm in length, finely toothed on the margin; deeply furrowed gray bark. Flowers are loose catkins 10-15 cm long. The tiny seeds have attached fluffy fibers to carry them long distances.

BLACK COTTONWOOD
(Populus trichocarpa)

12b. Leaf blades light green beneath, the two surfaces not sharply contrasted; twigs not greenish-orange; terminal buds slender.

NARROWLEAF COTTONWOOD

Slender tree up to 20 m tall. Greenish-white bark; has narrow lance-shaped leaves which are finely toothed; flowers are catkins. Cottonwoods also reproduce from stumps and root sprouts.

NARROWLEAF COTTONWOOD
(Populus angustifolia)

13a. Bud scales single, forming a cap over bud; leaves narrow. (14)

13b. Bud scales more than one; leaves not narrowed. (15)

14a. Leaves linear, 6 times as long as wide.

SLENDER WILLOW

Shrub with a gray color effect, as the leaves are hairy on both sides. Colonial, 2 to 4 meters tall occasionally becoming a slender tree to 8 meters in height, spreading underground and forming thickets.

SLENDER WILLOW
(Salix exiqua)

14b. Leaves lance-shaped, 2 times as long as wide.

BEBB WILLOW

Shrub with a few stems, or a small tree, 2 to 5 m in height; dull green leaves 2 - 5 cm long, are silvery white beneath with fine rusty hairs. Male catkins yellowish. Bark thin, grayish green. The Indians made fishlines out of the stringy inner bark.

BEBB WILLOW
(Salix bebbiana)

15a. Catkins present in winter, sometimes difficult to find. (Look high in the tree tops.) (16)

15b. Catkins never present in winter, old fruit sometimes present. Oval to circular lenticles conspicuous.

CHOKECHERRY

Shrub or tree up to 10 meters high. Finely toothed leaves are ovate or oblong. Fruit dark purple to red or black, 8 to 10 mm in diameter, edible, but rather acid, and make excellent jell. Eaten fresh or dried and used as an ingredient of Pemmican by Indians.

CHOKECHERRY
(Prunus virginiana)

16a. Buds raised on short stalks, pith triangular; stems lack small crosswise streaks on older stem.

THINLEAF ALDER

Large shrub or small tree that grows to 8 m tall. Egg-shaped leaves have double toothed margins, are grass green on upper surface, light yellow green below. Bracts of female flowers become woody, resembling a miniature pine cone. Common near stream edge.

THINLEAF ALDER
(Alnus tenuifolia)

16b. Buds not raised on short stalks, pith rounded; older stems with small streaks cross wise.

WATER BIRCH

Small tree to 10 m tall, may form dense thickets along stream and in swampy area. Bark is thin, smooth and dark bronze, marked by horizontal lenticels. Leaves ovate, sharply toothed and often lobed. Flowers are small in catkins. Wing of fruit much wider than fruit body.

WATER BIRCH
(Betula occidentalis)

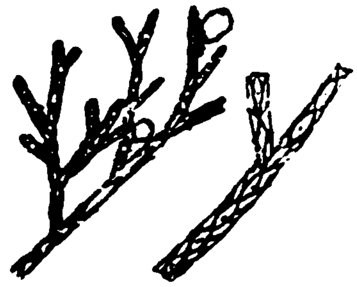
17a. Broad leaved shrubs. (19)

17b. Leaves awl-shaped, or scale-like; blue berry like fruit usually present. (18)

18a. Leaves scale-like, 4 ranked, pressed to the stem. (4b)

ROCKY MOUNTAIN JUNIPER

A tall shrub or small tree up to 12 meters in height. The branches are long and drooping. The seed is berrylike, small, smooth and green or bluish. The trunk is short and stout, often divided near the ground. The wood of these trees is soft and durable and is used primarily for fence posts.



ROCKY MOUNTAIN JUNIPER
(Juniperus scopulorum)

18b. Leaves awl-shaped, or spiny, with a white line on one surface, in whorls of three.

COMMON JUNIPER

Low, spreading shrub which forms dense patches on the ground 6 - 9 dm in depth. Leaves are arranged in whorls of 3. Seed cones (berries) are 12 mm in diameter, green becoming dark blue with a bloom. Junipers play an important part in Indian ceremonials and legend and as a source of medicine, food, and dye.

COMMON JUNIPER
(*Juniperus communis*)

19a. Plants evergreen, bud not found at the axis of the petiole and the stem. (20)

19b. Plants not as above, leaves deciduous, bud usually found at the axis of the petiole and stem. (21)

20a. Leaves toothed, holly-like; plants growing next to ground.

OREGON GRAPE

Low shrub from underground rootstocks. Leathery leaves have 3 holly-like leaflets with 10 or more small teeth. Flowers bright yellow, fruit dark blue, pear-shaped. State flower of Oregon.

OREGON GRAPE
(*Berberis repens*)

20b. Leaves oblong, 1-2 cm in length; low creeping shrub.

KINNIKINNICK

Main stem prostrate, forming mats. Leaves are 1-2 cm long, leathery, round to subacute at tip. Flowers bell-shaped, white or pink, in short few-flowered racemes. Bears, Mountain sheep, deer and birds eat the red fruits; bark and leaves of the plant were dried and smoked in place of tobacco.

KINNIKINNICK
(*Arctostaphylos uva-ursi*)

21a. Stems with spines or prickles. (22)

21b. Stems without spines or prickles. (27)

22a. Spines with a shieldlike base; buds small and shiny; leaves compound. (23)

22b. Spines without a shieldlike base; buds neither small nor shiny; leaves simple. (24)

23a. Fruits usually solitary; petals 2 - 4 cm long; spines arising below leaf scar two but not stout; internodal spines few or absent.

NOOTKA ROSE

Found at higher elevations than Woods rose. Flower is rose-colored, rarely white, sepals 5, petals 5. Fruit a purplish "hip".

NOOTKA ROSE
(*Rosa nutkana*)

23b. Fruits usually several in a cluster; petals 1.5 - 2.5 cm long; spines arising below the leaf scar stout and paired; internodal spines generally sparse or absent.

WOODS ROSE

Sepals 5, petals 5, rose-colored inflorescence a few-flowered cyme. After the petals fall, the pistils and their cup-like receptacle become a rose "hip", which provides food for wildlife.

WOODS ROSE
(*Rosa woodsii*)

24a. Spines 2 cm or greater in length; tall shrub, greater than 2 m; mature fruit black.

BLACK HAWTHORN

Spines red, becoming gray with age; grows in thickets. Buds alternate, sessile, small and round. Flowers are white in clusters. Apple-like red fruits, called "haws", provide birds and small mammals with food.

BLACK HAWTHORN
(*Crataegus douglasii*)

24b. Spines less than ½ cm in length; shrub less than 1 m in height. (25)

25a. Leaves compound, white underneath; no distinct nodal spines.

RASPBERRY

Three to five leaflets, doubly serrate, glabrous above, white woolly hair below. Erect stems are prickly. White flowers about 2 cm across or less, fruits a light red, and sweet.

RASPBERRY
(*Rubus idaeus*)

25b. Leaves simple, green on both sides; distinct nodal spines. (26)

26a. Rigid brown spines, nodal spines 3 - 9, internodal numerous. Over 4 flowers in each raceme. Hypanthium shallowly cup or saucer-shaped.

PRICKLY CURRANT

Spiny, medium shrub, leaves toothed, lobed over ½ length. Flowers 4 to 10 in a raceme; light green or purplish berries 6 to 8 mm in diameter, covered with purple-tipped glandular hairs.

PRICKLY CURRANT
(*Ribes lacustre*)

26b. Nodal spines very stout, 3 (occasionally 1 or 2 with additional smaller spines). Internodal spines few, weak. Flowers 1 to 4 in each raceme. Hypanthium tube or bell-shaped.

REDSHOOT GOOSEBERRY

Shrub, usually less than 1 m high, with bristly arched or recurved branches. Buds alternate. Leaf blades thin, 1 - 4 cm wide, finely haired. Berry red to black, somewhat bristly, or smooth. Very common.

REDSHOOT GOOSEBERRY
(*Ribes setosum*)

27a. From 21b. Leaves or buds opposite. (28)

27b. Leaves or buds alternate. (32)

28a. Stems hollow; fruits or flowers in irregular clusters of several to many; bundle scars 1.

SNOWBERRY

Erect shrub, 20 - 80 cm tall; leaves short-petioled, opposite, oval to egg-shaped, entire or somewhat sinuate. Flowers white or pinkish in crowded clusters in leaf axils and ends of branches. Petals form corolla tube. Berries white, two seeded, eaten by many kinds of birds.

SNOWBERRY
(*Symphoricarpos albus*)

28b. Stems not hollow. (29)

29a. Leaves simple; in dormant stage pith less than 3/4 of twig. (30)

29b. Leaves compound, in dormant stage have 3 - 5 prominent leaf scar bundles, with pith 3/4 of twig.

BLACK ELDERBERRY

Shrubs up to 3 m tall; leaves pinnately compound, leaflets 5 - 7, oval, serrate. Reddish brown branches. Flowers white in a cyme 5 - 7 cm wide. Berries black.

BLACK ELDERBERRY
(*Sambucus melanocarpa*)

30a. Stems or at least part of them conspicuously red. (31)

30b. Stems not conspicuously red; leaves spotted beneath with brownish scales.

CANADIAN BUFFALOBERRY

Shrub 1 to 3 m high; opposite leaves. Flowers yellowish, appear in June, are inconspicuous as the petals are missing. Red-orange berries appear in August. They are very bitter, but are a source of food for wildlife.

CANADIAN BUFFALOBERRY
(*Shepherdia canadensis*)

31a. Leaflets deeply lobed (maple-shaped) bud scales valvate.

ROCKY MOUNTAIN MAPLE

Leaves are three to five lobed; plant is usually less than twelve feet in height. Twigs with dark red bark, older stems with smooth gray bark. In certain areas a tiny mite stimulates formation of brilliant red galls on the leaves.

ROCKY MOUNTAIN MAPLE
(Acer glabrum)

31b. Leaflets not toothed or lobed; buds naked, enclosed by a pair of small leaf-like structures.

RED DOGWOOD

Shrub 1 - 3 m high, bark of older stems grayish brown young twigs olive green becoming reddish purple. Leaves ovate 3 to 10 cm long. Flowers white, in a cyme. Petals four. White or bluish berries.

RED DOGWOOD
(Cornus stolonifera)

32a. From 27b. Bud scales single, forming a cap over bud. (33)

32b. Bud scales more than one. (34)

33a. Leaves linear, 6 times as long as wide.

SLENDER WILLOW

Shrub 2 - 4 m high; color effect grayish. Leaves 5 - 12 cm long, mostly entire. Bark is rough and fissured on the trunk, but brown, shiny and smooth on the branches. Yellow catkins appear with the leaves.

SLENDER WILLOW
(Salix exiqua)

33b. Leaves lance-shaped, 2 times as long as wide.

BEBB WILLOW

Shrub with a few stems, or a small tree, 2 to 5 m high; dull green leaves 2 - 5 cm long, are silvery white beneath with fine rusty hairs. Male catkins yellowish. Bark thin, grayish green. The Indians made fishlines out of the stringy inner bark.

BEBB WILLOW
(Salix bebbiana)

34a. Buds valvate; leaves smooth edged, or toothed under magnification. (35)

34b. Buds not valvate; leaves toothed or lobed. (36)

35a. Young twigs angled or winged, ending in a broom of small branches, stems green; low plants 1-4 dm high, leaves 5-12 mm long.

LOW RED HUCKLEBERRY

Also called Whortleberry. Low, tufted shrub - - 4 dm high. Flowers solitary in the axils of the stems. Corolla light or dark pink, be·.ies are bright pink. Bears are fond of the berries, as also are birds and people.

LOW RED HUCKLEBERRY
(Vaccinium scoparium)

35b. Plants 1 to 2 m high, stems not ending in a broom of fine branches. Leaves close to 2 to 6 cm long and is more than $1\frac{1}{2}$ times longer than wide; some stems reddish.

THINLEAF HUCKLEBERRY

Erect branching shrub 1 - 2 m high. Flowers solitary in the axils, yellowish. Berry is dark wine-colored or purplish black, and edible. In winter there is a short projection of stem tip beyond the apparent "terminal" bud. True terminal bud is missing.

THINLEAF HUCKLEBERRY
(Vaccinium membranaceum)

36a. Bark naturally shredding into long strands or thin plates on 2 and 3 year old stems. (37)

36b. Bark not shredding. (39)

37a. Leaves not lobed, only toothed, ovate-oval, 2 to 4 cm long, teeth large, 4 to 5 per inch.

SPIRAEA

Leaves ovate-oval, 2 - 4 cm long, finely serrate at least $\frac{1}{2}$ their length. Bright green on upper surface, paler and strongly veined beneath. Bark reddish or purplish brown. Petals pink to rose

SPIRAEA
(Spiraea densifolia)

37b. Leaves lobed and toothed. (38)

38a. Leaves 3 to 5 palmately lobed, doubly toothed, 6 to 15 cm long; gray-brown flaky bark. Pith more than $\frac{1}{2}$ stem diameter.

THIMBLEBERRY

Leaves 3 to 5 palamately lobed, the lobes are triangular, leaves are also doubly dentate-serrate. Older stems are gray-brown, shreddy or flaky. Flowers white, $2\frac{1}{2}$ to 5 cm across, 5 petals. Fruits large, raspberry-like, red to salmon red.

THIMBLEBERRY
(Rubus parviflorus)

38b. Leaves almost always 3 palmately lobed, doubly toothed, 4 to 8 cm long. Older stems gray, shreddy, revealing light-colored innerbark. Pith less than ½ stem diameter.

NINEBARK

Shrub .5 to 2 m tall. Leaves green above, pale beneath, 4 - 8 cm long, usually 3 palmately lobed and doubly toothed. Petals usually white, stamens 20 - 40. Inflorescence in terminal corymb.

NINEBARK
(*Physocarpus malvaceus*)

39a. Leaves only toothed, flat or broad rounded across tip. Lower half of blade not toothed. Margin of bud scales with little hairs.

SERVICEBERRY

Shrub 1 to 4 m tall. White flowers in few-flowered clusters, 5 petals. Fruit berry-like, deep purple and juicy but tasteless. An important browse species for deer and elk, and one of the first shrubs to be eliminated on overbrowsed ranges.

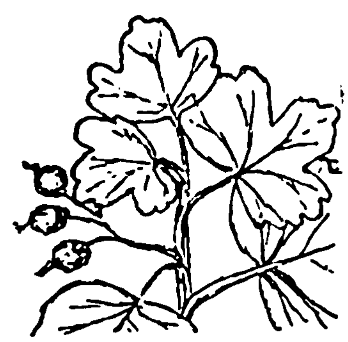
SERVICEBERRY
(*Amelanchier alnifolia*)

39b. Leaves lobed, not as above (40)

40a. Leaves three, occasionally five lobed, segments entire or with 2 to 5 rounded teeth. Branches glabrous to finely pub rulent; flowers yellow.

GOLDEN CURRANT

1 to 3 m tall with tube-shaped yellow flowers that form racemes in the axils of leaves. They have a pleasant spicy odor. Leaves are 3 - 5 lobed, often toothed. Fruit when mature is black, red or yellow.

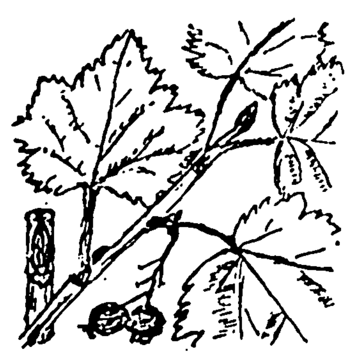


GOLDEN CURRANT
(*Ribes aureum*)

40b. Leaves 3 to 5 lobed, toothed. If 5 lobed, lower segments usually very unequally lobed. Flowers white.

HUDSON CURRANT

Shrub .1 to 1.5 m tall, glandular all over with sessile, round, yellow, crystalline and shining glands with a strong, sweet rather unpleasant odor. Leave broader than long, 3 - 5 lobed, pale and hairy on lower surface. Petals white, berry bitter and black.



HUDSON CURRANT
(*Ribes hudsonianum*)

ASPEN ECOSYSTEM

Patches of Aspen occur on lower mountain slopes near the mountain front near springs and seeps or where ground water is near the surface. It is interspersed with the Douglas fir and lodgepole pine ecosystems and may project into the grassland. Aspen occur in the lower elevations usually below 7,500 feet. This ecosystem has been separated from streamside hardwood because little or no surface water is associated with this ecosystem and because it occurs on steeper slopes.

Soils are 30 to 150 cm deep, originating from similar materials as those of Douglas fir and lodgepole pine ecosystems. Best development of aspen occurs on soils that are of limestone origin, are high in humus, and are porous and loamy. Ground water levels are usually between 0.5 and 1.5 m below the soil surface.

The aspen ecosystem is more diverse and productive than the surrounding areas. Wildlife use this area for both food and cover. Moose, elk, and deer frequent aspen stands, especially during the summer months. Ruffed grouse nest and feed here. A variety of songbirds nest in the trees and shrubs and on the ground.

Aspen and its associated species have high moisture and nutrient requirements. In turn it also improves soils it is invading by recycling nutrients to the soil through leaf fall. Fire, cutting, or any other type of overstory removal plays an important part in the maintenance of this ecosystem. Seedling development and reproduction from root suckers requires much might. A young stand is also more important for browse than an older stand which grows out of reach of wildlife.

KEY
TO THE COMMON PLANTS OF
THE ASPEN ECOSYSTEM

1a. Woody plants, may be only woody at base. (2)

1b. Plants herbs, dies annually, at least down to the ground.

2a. Tree like, one central stem, usually greater than 3 meters in height. Broad leaved. Bark yellow-green, with dark branch scars.

QUAKING ASPEN

Leaf blades are round or heart shaped, ciliate on the margin. Long, flat petiole causes leaves to tremble with the slightest breeze. The tree often develops abundantly after a forest fire and forms dense groves, especially in moist places.

QUAKING ASPEN
(Populus tremuloides)

2b. Shrub-like, more than one central stem, less than 3 meters in height. (3)

3a. Stems with spines or prickles; fruits usually several in a cluster; spines arising below the leaf scar stout and paired.

WOODS ROSE

Sepals 5, petals 5, rose-colored inflorescence a few-flowered cyme. After the petals fall, the pistils and their cup-like receptacle become a rose "hip", which provides food for wildlife.

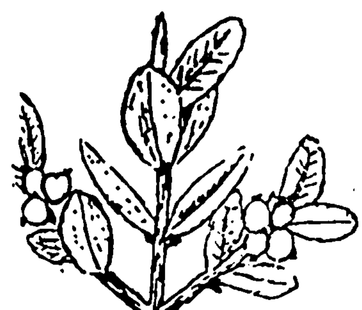
WOODS ROSE
(Rosa woodsii)

3b. Stems without spines or prickles. (4)

4a. Leaves or buds opposite; stems hollow; fruits or flowers in irregular clusters of several to many.

SNOWBERRY

Erect shrub, 20 - 80 cm tall; leaves short-petioled, opposite, oval to egg-shaped, entire or somewhat sinuate. Flowers white or pinkish in crowded clusters in leaf axils and ends of branches. Petals form corolla tube. Berries white, two seeded, eaten by many kinds of birds.

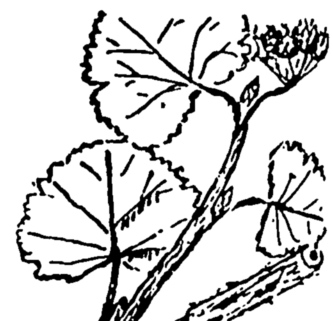


SNOWBERRY
(Symphoricarpos albus)

4b. Leaves or buds alternate, leaves almost always palmately lobed, doubly toothed. Older stems gray, shreddy, revealing light-colored inner-bark.

NINEBARK

Shrub .5 to 2 m tall. Leaves green above, pale beneath, 4 - 8 cm long, usually 3 palmately lobed and doubly toothed. Petals usually white, stamens 20 - 40, Inflorescence in terminal corymb.



NINEBARK
(Physocarpus malvaceus)

ROCK OUTCROP - FOREST ECOSYSTEM

This ecosystem represents an intermediate stage between forest ecosystems and bare rock outcrop. It is characterized by scattered individual trees and patches of trees among bare rock outcrops. The topography consists of steep mountain slopes, river faces, and cliffs. The elevation range includes Douglas fir, lodgepole pine, and subalpine forest ecosystems.

Geology includes granitic, metamorphic, volcanic and limestone rocks. The soils developed in this ecosystem are very shallow and skeletal and occur as isolated patches in protected pockets and more level slopes.

Less snow cover and warmer microclimate on the steep south slopes of this ecosystem make it a valuable wintering area for wildlife. It provides valuable forage because of less snow accumulation and cover from storms in the form of timber thickets. The rocky ledges provide habitat for bighorn sheep and mountain goats. They also provide nesting areas for golden eagles and prairie falcons. The steep slopes provide updrafts to carry broadwinged hawks and eagles aloft for hunting. The lower south facing slopes become exceedingly dry and hot during summer months.

The rock-outcrop-forest ecosystem rates low in production, except for water which is yielded as runoff. The rock outcrop and talus parts of this ecosystem are maintained by the steepness of slopes and continuous fall and movement of rock down the slopes. The accumulation of colluvium in depressions and on gentler slopes provide growing sites for vegetation, which develops soil. Water is collected in these depressions, providing moisture for the plants.

KEY
TO THE COMMON PLANTS OF
ROCK OUTCROP - FOREST ECOSYSTEM

1a. Woody plants, may be only woody at base. (2)

1b. Plants herbs, dies annually, at least down to the ground.

2a. Tree-like, one central stem, usually greater than 3 meters in height. (3)

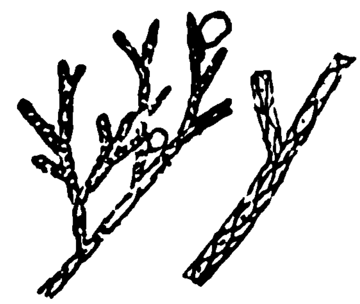
2b. Shrub-like, more than one central stem, usally less than 3 meters in height. (7)

3a. Trees with needle-like leaves, seed is in a cone (4)

3b. Trees with scale-like leaves, seed is berry-like

ROCKY MOUNTAIN JUNIPER

A tall shrub or small tree up to 12 meters in height. The branches are long and drooping. The seed is berrylike, small, smooth and green or bluish. The trunk is short and stout, often divided near the ground. The wood of these trees is soft and durable and is used primarily for fence posts.



ROCKY MOUNTAIN JUNIPER
(Juniperus scopulorum)

4a. Evergreen trees with needle-like leaves, needles in bundles of two or more. (5)

4b. Evergreen trees with needle-like leaves, that are single, not in bundles. (6)

5a. Leaves in clusters of 2 or 3, less than 10 cm in length, cones usually about 5 cm in length.

LODGEPOLE PINE

Needles $2\frac{1}{2}$ - $7\frac{1}{2}$ cm long; lopsided cones with sharp spines. Grows in dense stands, losing the lower branches as they become shaded. Cones often remain closed for many years. Heat of a fire usually will cause them to open and reseed the area.

LODGEPOLE PINE
(Pinus contorta)

5b. Leaves in clusters of 5, cones 7 - 13 cm long or longer.

LIMBER PINE

Usually a twisted and stunted tree from 10 - 15 meters tall. Bark is thin, smooth, light gray on younger trees, dark brown and plated on older. Needles in clusters of five, $2\frac{1}{2}$ to 3 cm long. Cones 1 - $1\frac{1}{2}$ dm long, young branches exceptionally limber. This characteristic allows this plant to withstand severe winds.

LIMBER PINE
(Pinus flexilis)

6a. Needles flat, narrowed at base; cones hang downward, cones with prominent 3-pointed bract.

DOUGLAS FIR

The flat needles are borne singly and grow around the branch giving it a full appearance. "Neptune's tridents", the three-pronged bracts between the cone scales are found in both immature and mature cones. The bark is gray-brown with resin blisters in young trees becoming deeply grooved gray-brown cork-like in older ones. A very valuable lumber tree and also as Christmas trees.

DOUGLAS FIR
(*Pseudotsuga menziesii*)

6b. Needles flat, nat narrowed at base; cones point upward.

ALPINE FIR

Smooth gray bark of young trees is unique because of the many lens-shaped blisters. Seed cones are barrel-shaped, dark purple. As the result of heavy snows, the lower branches often become rooted forming a circle of smaller trees. Such a colony is called a snowmat.

ALPINE FIR
(*Abies lasiocarpa*)

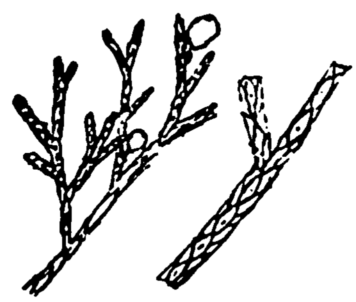
7a. Broad-leaved shrubs. (9)

7b. Leaves awl-shaped, or scale-like; blue berry-like fruit usually present. (8)

8a. Leaves scale-like, 4 ranked, pressed to the stem.

ROCKY MOUNTAIN JUNIPER

A tall shrub or small tree up to 12 meters in height. The branches are long and drooping. The seed is berrylike, small, smooth and green or bluish. The trunk is short and stout, often divided near the ground. The wood of these trees is soft and durable and is used primarily for fence posts.



ROCKY MOUNTAIN JUNIPER
(*Juniperus scopulorum*)

8b. Leaves awl-shaped or spiny with a white line on the surface, in whorls of three.

COMMON JUNIPER

Low, spreading shrub which forms dense patches on the ground 6 - 9 dm in depth. Leaves are arranged in whorls of 3. Seed cones (berries) are 12 mm in diameter, green becoming dark blue with a bloom.

COMMON JUNIPER
(*Juniperus communis*)

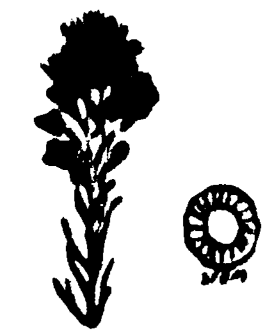
9a. Stems with spines or prickles (11)

9b. Stems without spines or prickles (10)

10a. Leaves linear, entire, white-woolly.

RUBBER RABBITBRUSH

Low half-shrub, 4 - 8 dm high. Has numerous small heads of yellow or orange disk flowers. Bark is rough or shreddy, remnants of old flower heads often present in winter. Used by Hopi Indians for arrows and wickerwork.



RUBBER RABBITBRUSH
(Chrysothamnus nauseosus)

10b. Leaves compound, leaflets 3, rather strongly aromatic when crushed.

SKUNKBUSH SUMAC

Shrub 3 to 15 dm tall. Terminal leaflet 3 lobed and coarsely toothed, lateral leaflets smaller, scarcely lobed. Flowers yellowish, appearing before the leaves in short spike-like clusters. Fruit bright orange-red, flattened, sticky hairy.

SKUNKBUSH SUMAC
(Rhus trilobata)

11a. Spines with a shieldlike base; buds small and shiny; (12)

11b. Spines without a shieldlike base; buds neither small nor shiny; leaves simple. (13)

12a. Fruits usually solitary; petals 2 - 4 cm long; spines arising below leaf scar two but not stout; internodal spines few or absent.

NOOTKA ROSE

Found at higher elevations than Woods Rose. Flower is rose-colored, rarely white, sepals 5, petals 5. Fruit a purplish "hip".

NOOTKA ROSE
(Rosa nutkana)

12b. Fruits usually several in a cluster; petals 1.5 - 2.5 cm long; spines arising below the leaf scar stout and paired; internodal spines generally sparse or absent.

WOODS ROSE

Sepals 5, petals 5, rose-colored inflorescence a few-flowered cyme. After petals fall, the pistils and their cup-like receptacle become a rose "hip", which provides food for wildlife.

WOODS ROSE
(Rosa woodsii)

13a. Leaves compound, white underneath; no distinct nodal spines.

RASPBERRY

Three to five leaflets, doubly serrate, glabrous above, white woolly hair below. Erect stems are prickly. White flowers about 2 cm across or less, fruits a light red, and sweet.

RASPBERRY
(Rubus idaeus)

13b. Leaves simple, green on both sides; distinct nodal spines. (14)

14a. Bark on young stems reddish to orange brown.

REDSHOOT GOOSEBERRY

Shrub .5 to 1 m tall. Branches finely puberulent, 1 to 5 nodal spines, internodal spines few. Leaves 1.5 to 4 cm wide, 5 lobed ½ length or less. Berry a deep purplish black.

REDSHOOT GOOSEBERRY
(Ribes setosum)

14b. Bark on young stems brown, gray, or straw colored (13)

15a. Leaves with hairy and glandular pubescence.

PRICKLY GOOSEBERRY

Shrub 3 to 6 dm high. Nodal spines 3 to 5, usually also bristles. Leaves 1 to 2.5 cm broad. Irregularly lobed. Fruit a reddish berry, glandular bristly. Found in alpine and subalpine areas.

PRICKLY GOOSEBERRY
(Ribes montigenum)

15b. Leaves glabrous, or nearly so.

PRICKLY CURRANT

Shrub 1 to 2 m high. Nodal spines 3 to 9. Leaves 2 to 5 cm long and broad, cleft 3/4 their length, divisions into acute teeth. Berries a dark purple, densely glandular and hairy.

PRICKLY CURRANT
(Ribes lacustre)